104

THE FUTURE OF ANTARCTIC RESEARCH

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The Future of Antarctic Research, H...

HEARING

BEFORE THE

SUBCOMMITTEE ON BASIC RESEARCH

OF THE

COMMITTEE ON SCIENCE

U.S. HOUSE OF REPRESENTATIVES

ONE HUNDRED FOURTH CONGRESS

SECOND SESSION

JULY 23, 1996

[No. 65]

Printed for the use of the Committee on Science

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*Ranking Minority Member
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THE FUTURE OF ANTARCTIC RESEARCH

TUESDAY, JULY 23, 1996

U.S. House of Representatives,
Committee on Science,
Subcommittee on Basic Research,
Washington, DC.

The Subcommittee convened at 1:32 p.m. in Room 2318 of the Rayburn House Office Building, the Honorable Steven H. Schiff, Chairman of the Subcommittee, presiding.

Members present: Representatives Schiff, Cramer, Ehlers, Luther, Gutknecht, Graham, Volkmer and Morella.

Chairman Schiff. The Subcommittee is called to order.

Today the Subcommittee is continuing its oversight responsibilities of the National Science Foundation. The focus of this hearing is the United States Antarctic Program and the future of Antarctic research.

Antarctica, with ten percent of the Earth's land mass, is nearly 1.5 times the size of the United States. Its associated seas represent over five percent of the world's oceans and its ice—70 percent of the earth's fresh water. The United States has important foreign policy, national security, scientific and environmental interests in this vast area.

Historically a strong year-round U.S. presence in Antarctica in the form of scientific research supported by permanent infrastructure at three research stations has been the principal means of realizing these interests. Some of the infrastructure is nearing the end of its design life and is in need of replacement. The estimated price of replacement is substantial, and this combined with current and anticipated budget constraints raises important issues concerning the U.S. Antarctic Program.

The responsibilities of the United States, our commitment to the Antarctic and our role at the South Pole Station are topics I hope to address in today's hearing. Some of my specific questions include:

—In these changing political times, what continued role should the U.S. play?

—How much is the international community willing to contribute to the research infrastructure, and what role should they play?

—In reviewing the entire United States science budget, how much resources can and should be dedicated to polar research?

—With cost estimates for the South Pole Station ranging from $90 million for a 25-person station to $225 million for a 200-person station, which bracket the National Science Board's approval of continued planning for a 110-person enhanced version of the Station for $181 million, what is the preferred course of action of the Administration and scientific community?

—In these difficult fiscal times, are researchers willing to absorb the cost of rebuilding the South Pole Station from operational and scientific supporting funding?

—Currently, the logistical support for the U.S. Antarctic Program is being transferred from the U.S. Navy to the Air National Guard. How is the transition going; and what, if any, new costs will be incurred by the National Science Foundation?

Recently, at the direction of the United States Senate, the National Science and Technology Council conducted a comprehensive review of the United States Antarctic Program and published a report in April. This document represents a sound analysis to further discussions of the future of the USAP. We will hear more today of this report's conclusions and recommendations.

We have organized this hearing in two panels. First, we will hear from representatives of the Office of Science and Technology Policy, the National Science Foundation, and the Departments of State and Defense; and, second, two scientists representing the Polar Research Board of the National Academy of Sciences.

I would to now recognize my Ranking Minority Member, Mr. Cramer, for any opening remarks he might like to make.

Mr. CRAMER. Thank you, Mr. Chairman, and I will be brief. I'm glad we're having the hearing today, and I'm pleased to join you in welcoming our distinguished witnesses today.

I think it's important that we reflect very carefully on what you have to report to us today because the National Science and Technology Council has given us this report. We need to do periodic reviews of programs like this because we, in this atmosphere, have to evaluate what we can afford, what our priorities should be, what needs to be dusted off, reinvested in, and where are we.

Of course, this report has explicitly recommended retaining all three permanent U.S. Antarctic Stations. What I would ask you to think about as you testify here today is to tell us what you see in terms of budget consequences of what we need to do with the program. I mean I'm fully committed to the program, and I think this Committee is fully committed to the program, but we've got some tough alternatives to face. So I want your help in doing that. We confront a wide range of research opportunities through this Committee and through the Congress itself. So we've got to balance exactly what we do do.

So I look forward to your testimony today. I think there are other questions that I will have, and I'll wait until we get to the question time to do that.

I will say, Mr. Chairman, that I think we've got to make a decision about whether we go forward with a rebuilding of the U.S. permanent station there, and I'm in favor of that, and I want to help this Committee in any way I can.

That's all I have at this time.

Chairman SCHIFF. Thank you, Mr. Cramer.

Mr. Luther, do you desire to make any opening statement?

Mr. LUTHER. No. Thank you.

Chairman SCHIFF. Before introducing panel Number One, there are two things I would like to mention first.

The first is for those who have been at Congressional hearings before, this is old hat. For those of you haven't, we could be interrupted by votes and other matters before the Congress, and I apologize for that, but it's just the nature of our institution because so many things are going on at once.

Second of all, if you've not been at a Congressional hearing before, and again I suspect most of you have, it's kind of a natural question to look around the room and say where is everybody. Actually the majority of hearings are probably held with the Chair and the Ranking Minority Member being present. The fact of the matter is the real effectiveness of a hearing is in the record that the court reporters are taking down, which in due course will be made available to the entire Congress when they consider the issues that are involved in this hearing.

So I can assure you that regardless of what number of Members are in the hearing room or what comings and goings you may see, that serious attention will be paid to all the testimony here.

Finally, before I introduce the panel, I'm told that the National Science Foundation has prepared about a five-minute video, and I would ask unanimous consent to allow them to play the video before we call the first panel, and hearing no objection whoever has got their hand on the button please go ahead.

[Video shown.]

Chairman SCHIFF. I would like to thank the National Science Foundation for that introductory film, and I would like now to introduce our first panel.

The first panel consists of:

The Honorable Ernest Moniz, Assistant Director for Science of the Office of Science and Technology Policy in the Executive Office of the President;

Dr. Neal Sullivan, Director of the Office of Polar Programs of the National Science Foundation;

Mr. R. Tucker Scully, Director of Office of Ocean Affairs of the U.S. Department of State; and

Mr. Robert Pirie who is Assistant Secretary of the Navy for Infrastructure and the Environment of the Department of Defense.

Gentlemen, without objection, your written statements, if you have provided them, will be made a permanent part of this hearing and you're welcome to proceed in summary in such fashion as you desire.

So can we start on my left with Dr. Moniz.

STATEMENT OF THE HONORABLE ERNEST J. MONIZ, ASSOCIATE DIRECTOR FOR SCIENCE, OFFICE OF SCIENCE AND TECHNOLOGY POLICY, EXECUTIVE OFFICE OF THE PRESIDENT

Mr. MONIZ. Mr. Chairman and Members, I'm pleased to appear before you today to discuss the recent report on the U.S. Antarctic Program issues in April by the Committee on Fundamental Science, or CFS, of the NSTC.

My discussion today will focus on describing the process involving multiple agencies that led to the report, as well as its principal conclusions. The report expresses the Administration's renewed commitment to a continuing active and influential presence in Antarctica.

In 1982, Presidential Memorandum 6646 established the current framework for U.S. policy in the Antarctic, an active and influential presence, year-round occupation of two coastal stations and the South Pole Station, and continuing single-point management by the NSF.

The NSTC activity report re-examined this policy in light of the very different conditions that pertain today. A substantially-altered geopolitical climate; a highly-constrained fiscal environment; and the discussions concerning replacement of South Pole Station.

The report was produced and responds to the Congressional request for a view of the USAP by the NSTC. Jack Gibbons assigned responsibility for the review to the CFS which I co-chair. The committee formed an ad hoc working group on the USAP that had members from twelve agencies, and I stress that the report represents the full consensus and concurrence of all the agencies.

In evaluating the program, we relied upon the published record, various program descriptions, discussions with scientists and visits to the Antarctic during the last austral summer by four CFS principals with very different science and management backgrounds, myself, and I'm a physicist who previously managed a DOE laboratory; Dr. France Cordova, NASA's Chief Scientist, an astrophysicist who took part in the recent restructuring of NASA's scientific operations; Dr. Anita Jones, a computer scientist in DDR&E at Defense; and Dr. Harold Varmus, the Nobel Prize-winning biomedical researcher who directs the NIH.

All four of us developed a common impression of high quality and high interest in the science. In addition, we were able to evaluate the operation and status of the infrastructure. We feel confident that we gained in this process sufficient information to draw substantial conclusions and make substantive recommendations, which I will now summarize from the report, although in a different order.

First, the NSTC finds the USAP research program to be of very high quality and of great interest to a broad scientific community.

The report identified three broad thrusts of Antarctic science: understanding the Earth and its large-scale systems; the Antarctic as a unique natural laboratory; and exploration of the still not well-explored geographical frontier. We concluded that the USAP is substantially increasing our knowledge in each of these areas and examples are given in the report.

The second finding. From a policy perspective, the NSTC finds that maintaining an active and influential presence in Antarctica, including year-round operation of the South Pole Station, is essential to U.S. interests. Included in the report is a Department of State memorandum that attests to our ongoing geopolitical interests in Antarctica, and Mr. Scully will discuss this in more detail.

Our third finding. The NSTC review found that the NSF has implemented U.S. policy in an effective manner, especially by substantially improving environmental stewardship, by broadening the science program and by privatizing some operational elements of the program to reduce costs.

The USAP, we found, is continuously improving its managerial processes and its environmental approach—saving money as well as increasing efficiency. The USAP is also reorganizing some military functions and transferring some functions from military to civilian contractors.

The program has already saved $3.2 million annually, and by creating single-point management of USAP airplanes, an additional $10 million in annual savings is expected by the year 2000. Dr. Pirie will discuss this in more detail.

The fourth finding. The NSTC believes that at the current level of investment, the USAP is cost effective in advancing American scientific and geopolitical objectives; and from a science perspective supports the continuation of three stations with a year-round presence.

The program's principal infrastructure assets are its three stations, two research vessels and many summer field camps. McMurdo services the field camps and is the lifeline for the South Pole Station. Palmer, next to the Antarctic Peninsula and in a region of overlapping international claims, is the only U.S. station accessible year-round and is a center for marine research. South Pole Station, which sits at the convergence point of overlapping claims, occupies the most strategic geopolitical position and also makes possible unique science.

The complementary science programs and geopolitical considerations both argue against closing any of these stations or decommissioning ships; that is, the science lost would be incommensurate with the savings realized.

As for diminishing the program's year-round capability, NSTC also did not view this possibility as an attractive option at the current level of investment. The majority of the science at South Pole Station is performed during the austral winter and most of the maintenance at McMurdo is accomplished then, thereby holding down the summer population and minimizing environmental impact. Also, considerable overhead costs will be generated in restarting a station that has sat cold for many Antarctic winter months.

Given the constrained fiscal environment, of course, ongoing operational savings of the type described earlier will be important for preserving this level of science activity.

Our fifth finding. The USAP should give the highest priority to correcting critical health, safety and environmental issues at the current South Pole Station. Several deficiencies in the facilities at the South Pole require immediate attention. $25 million had been requested in FY 97 to effect the needed repairs, and we appreciate the support for this request expressed by the Congress.

NSTC recommends revisiting the issue of South Pole Station replacement. The current plans, which have been endorsed by the National Science Board and call for a 110-person enhanced station at a cost of about $181 million, were developed in a very different budget environment. This is not to suggest that the current plans are in any way excessive, but just that in this different funding environment, a fresh look at scope and cost is warranted.

The re-examination of station replacement plans should include discussions with potential international partners. However, the NSTC feels that the USAP must retain sufficient authority and operational control of South Pole Station so that U.S. safety and environmental standards are maintained and our geopolitical objectives continue to be fulfilled. Other international possibilities, some in the peninsula region, for example, might also be pursued.

In our sixth finding, NSTC recommends that an external panel be convened by NSF to explore options for sustaining the high level of USAP science activity under realistic constrained funding levels. The NSTC is well aware of the current budgetary environment and recognizes that Federal programs are being asked to do more with less.

The external panel will examine cost-saving options in detail. Where appropriate, the NSTC encourages the incorporation of alternate management approaches, remote observations and robotics to reduce costs. The NSF is putting together a panel of outstanding individuals with a variety of relevant operational and scientific experiences. Dr. Sullivan will discuss the panel's status.

This summarizes the main findings and recommendations of the NSTC. We appreciate this Committee's support of the USAP and are committed to working with Congress to advance the nation's goals in continuing our active and influential presence in Antarctica.

Thank you, Mr. Chairman.

Chairman SCHIFF. Thank you, Dr. Moniz.

[The prepared statement of Dr. Moniz follows:]

Testimony of

Dr. Ernest J. Moniz
Associate Director for Science
Office of Science and Technology Policy

before
The Committee on Science,
Subcommittee on Basic Research
U.S. House of Representatives

on the subject of
The Future of Antarctic Research

23 July 1996

Introduction

Mr. Chairman and members of the Committee, I am pleased to appear before you today to discuss the recent *Report on the United States Antarctic Program*, issued in April 1996 by the Committee on Fundamental Science (CFS) of the National Science and Technology Council (NSTC). It was produced in response to the Congressional request for a review of the United States Antarctic Program by the NSTC. My discussion today will focus on describing the concerted inter-agency process that led to the report, as well as the principal conclusions, which enjoy the support of all involved agencies. The report expresses the Administration's commitment to a continuing active and influential presence in Antarctica.

By presidential directive, the National Science Foundation has managed the USAP for the Federal government since 1982. That is. although the Antarctic research program has multiagency support, the special conditions in the Antarctic demand a single management organization for efficiency, cost effectiveness. and safety. Since the principal activity there is science, Presidential Memorandum 6646 assigned that responsibility to the National Science Foundation (NSF). That Memorandum. signed by President Reagan, also formally established the criterion of maintaining the USAP "at a level providing an active and influential presence in Antarctica" and mandated "year-round occupation of the South Pole [Amundsen-Scott] and two coastal stations [McMurdo and Palmer]." The NSTC activity reexamined this policy in light of the very different conditions that pertain today:

- a substantially altered geopolitical climate in the wake of the Cold War;
- a highly constrained fiscal environment;
- and the discussions concerning replacement of South Pole Station.

The U.S. has important foreign policy, national security, and environmental interests in Antarctica, but basic scientific research is the primary expression of our presence there. Thus, Dr. John H. Gibbons, the Assistant to the President for Science and Technology and the Director of the White House Office of Science and Technology Policy, assigned responsibility for the review to the CFS, which I co-chair with Dr. Neal F. Lane, the Director of the National Science Foundation, and Dr. Harold Varmus, the Director of the National Institutes of Health. We formed an ad hoc Working Group on the USAP that had, in addition to CFS member agency representation, individuals from other involved agencies (the National Security Council, the Department of State, the United States Coast Guard); the membership is identified in the report. I stress that the report represents the full consensus and concurrence of all the participating agencies.

In the remainder of this testimony, I shall briefly outline the principal scientific thrusts in the USAP, the geopolitical framework, the principal conclusions and recommendations, and the budgetary context.

USAP Science

All visitors to Antarctica come to know it as a unique region of Earth. Antarctica is defined by the Antarctic Treaty as the area south of 60 degrees south latitude. It contains 10 percent of Earth's land mass (about 1.5 times the area of the U.S.), 6 percent of the world's oceans, and its ice represents 70 percent of the earth's fresh water. Antarctica can be described in superlatives as the "coldest, windiest, highest, and driest" of Earth's continents. Thick continental ice — typically some three kilometers deep — covers 98 percent of the land; the remaining 2 percent is barren rock. This topology contrasts with North Polar regions. The Arctic Ocean is slightly larger than the Antarctic continent, but the Arctic surface is about three meters of moving ice on top of sea water. Furthermore, the Antarctic has no indigenous population.

The report identifies three broad thrusts of Antarctic science:

1. Understanding Earth and its large-scale systems.

Antarctica's oceans and ice affect Earth's atmosphere and seas, and Antarctica is an excellent platform from which to study large-scale phenomena such as global climate and sea-level changes and continental drift. Ocean "overturning," or ventilation, which removes carbon dioxide and gives heat to the atmosphere (thereby affecting climate), occurs south of the Antarctic Circumpolar Current. The ozone hole and the changes in the amount of ultraviolet radiation that reaches the ground are monitored from all three U.S. stations. And the west Antarctic ice sheet is the world's only remaining marine ice sheet; that is, the sheet is anchored to bedrock below sea level and the margins float. The sheet contains enough water to raise global sea levels six meters.

Because of the region's remoteness from centers of civilization and its consequent pristine nature. Antarctica is also an ideal place to make measurements that may show the influence of human activity on Earth's atmosphere and biosystem. For example, South Pole Station has a 37-year data set of measurements of atmospheric carbon dioxide.

2. Antarctica as a unique natural laboratory.

Antarctica also serves as a natural laboratory, with abundant opportunities for observations and experimentation. Most of the world's meteorites, for example, are found in Antarctica. Infrared astronomy takes advantage of the cold, dry air above the ice at the South Pole for clear, dark skies, making that area uniquely suited to ground-based infrared astronomy. And photodetectors for neutrino detection can be buried in the large, stable ice sheets themselves, eliminating a radioactive and or bioluminescence background and allowing observations of the entire northern sky at all times.

3. Exploration of the geographical frontier.

Advanced technology will help in the exploration of Antarctica's geographical frontier. The southern oceans are poorly known; multibeam swath bathymetry (swath mapping) by the R/V *Palmer* is imaging the ocean floor. Because Antarctica contains relatively few terrestrial and freshwater species, ecosystem dynamics can be studied more directly here. In the McMurdo Dry Valleys, the very slow decay preserves plant and animal fossil records from which climate information can be inferred. Antarctica also contains much geologic information of plate tectonic processes.

The Program's principal infrastructure assets — its three stations, two research vessels, and many summer field camps — support this broad USAP science by providing, in the words of the report, "unique research opportunities needed for major advances in many fields of science." They give the U.S. wide spatial coverage and year-round capability. Table III-1 (page 21) of the report, attached for your convenience, describes the distribution of USAP research funding, by discipline, across the stations and the ships.

The stations and ships complement each other's research and logistics capabilities. McMurdo services the field camps and is the lifeline for Amundsen–Scott South Pole Station. Palmer, next to the Antarctic Peninsula, is the only U.S. station accessible year-round and is a center for marine research. Its laboratories are a counterpart to work performed on R/V *Polar Duke*, and it is located in a region of overlapping territorial claims. South Pole Station, which sits at the convergence point of overlapping claims, occupies the most strategic geopolitical position and also makes possible unique science. The research vessels permit access to the Antarctic oceans, which aside from their geophysical importance are a rich source of marine biological information.

In evaluating this broad science, we relied upon the published record, various program descriptions, discussions with scientists, and visits to the Antarctic during the last austral summer by several CFS members: myself; Dr. France Cordova, NASA's Chief Scientist; Dr. Anita K. Jones, the Department of Defense's Director of Research and Engineering; and Dr. Varmus. My own visit took me to McMurdo Station, South Pole Station, several scientific field camps, and the research vessel *Nathaniel B. Palmer.* We observed strong international collaboration firsthand, both through collaborations with American scientists on U.S. projects and through our collaboration with other programs

The four CFS members, with vastly different scientific backgrounds, shared a uniform impression of the high quality of and high interest in the science. In addition, we were able to evaluate the operation and status of the infrastructure. We feel confident that we gained sufficient information to draw substantial conclusions and make substantive recommendations.

Geopolitical Framework

Modern activity in the Antarctic began with intense personal competition and was followed by continued national disputes over territorial claims. Scientific explorations occurred in the 1930s, and the U.S. has been the leader in Antarctic scientific research since the International Geophysical Year of 1957–58, which led to international cooperation with a scientific focus. The Antarctic Treaty, which was signed in 1959 and entered into force in 1961 with 12 nations active on the continent, formalized this cooperation and called science the primary purpose for human presence on the continent. More than that, as a Department of State memorandum included in the report points out, participation in the decision-making processes governed by the Treaty "requires demonstration of interest in Antarctica by the conduct of substantial scientific research there."

This Department of State memorandum, with the concurrence of the National Security Council, categorically attests to our ongoing geopolitical interests in Antarctica. The memorandum explains that the Treaty gives "concrete expression" to these interests, and the Department believes that the Treaty benefits this country more than any other. The ability to achieve U.S. interests through the Treaty is credited to the Nation's year-round presence, particularly at the South Pole.

Conclusions and Recommendations of the Report

For convenience, we summarize here the principal findings and recommendations:

1. From a policy perspective the NSTC finds that maintaining an active and influential presence in Antarctica, including year-round operation of South Pole Station, is essential to U.S. interests.

2. The NSTC review found that the National Science Foundation has implemented U.S. policy in an effective manner, especially by substantially improving environmental stewardship, by broadening the science program, and by privatizing some operational elements of the Program to reduce costs.

3. The NSTC finds the USAP research program to be of very high quality and of great interest to a broad scientific community.

4. The NSTC believes that, at the current level of investment, the USAP is cost effective in advancing American scientific and geopolitical objectives and, from a science perspective, supports the continuation of three stations with year-round presence.

5. NSTC recommends that an external panel be convened by NSF to explore options for sustaining the high level of USAP science activity under realistic constrained funding levels.

6. The USAP should give highest priority to correcting critical health, safety, and environmental issues at the current South Pole station.

Budgetary Context

To maintain the current scope of activity, the USAP now spends $196 million annually. One result of the review process was a recognition that certain single-point USAP managerial practices that save costs and increase efficiency also resulted in a classification of funds that was inconsistent with usual accounting of scientific grants and contracts. In the extreme conditions of the Antarctic, the logistical operational expenses consume about 64 percent of the funding, with research support, including grants to universities, taking the rest; see Table IV-1 (page 31), which shows the distribution of funding for science and support by facility, and is attached here for convenience. The total annual USAP cost is distributed as follows: Palmer Station, $12 million; South Pole Station $16 million; McMurdo and the field camps, $110 million; research vessels $22 million; and off-continent costs, $36 million. The McMurdo figure includes most aircraft and helicopter operations of the USAP. Extensive use of heavy-lift aircraft in Antarctica is unique to the USAP and directly influences the science quality by providing access and schedule flexibility.

The USAP is continuously improving its managerial processes and its environmental approach. Because of the "pack it in, pack it out" policy, more than five million pounds of waste are removed annually from Antarctica, and 70 percent of the waste is recycled.

The managerial improvements save money as well as increase efficiency. The USAP has shifted some tasks to the winter months, reducing the number of support staff in the demanding summer schedule by more than 200 persons.

USAP is also reorganizing some military functions and transferring some functions from military to civilian contractors: the Program has already saved $3.2 million annually.

And by creating single-point management of USAP airplanes, an additional $10 million in annual savings is expected by the year 2000.

The working group considered the significant savings possible from closing individual stations or decommissioning ships. The monetary savings and the loss of science can be read directly from the two attached tables. The NSTC concluded that none of these options is warranted at the current level of funding.

As for diminishing the Program's year-round capability, NSTC also did not see this possibility as a reasonable option. The majority of the science at South Pole Station is performed during the austral winter, and most of the maintenance at McMurdo is accomplished then (thereby holding down the summer population and minimizing environmental impact). Also, considerable overhead costs would be generated in "restarting" a station that had sat cold for many Antarctic winter months.

On the other hand, the NSTC is well aware of the current budgetary environment and recognizes that Federal programs are being asked to do more with less; the external panel will examine cost-saving options in detail. Where appropriate, the NSTC encourages the incorporation of alternate management approaches, remote observations, and robotics to reduce costs. The NSTC also encourages international collaboration to share costs, and it supports approaching potential partners for discussions. The USAP must, however, retain sufficient authority and operational control of South Pole Station so that U.S. safety and environmental standards are maintained and our geopolitical objectives continue to be fulfilled.

Although the NSF has developed plans to rebuild South Pole Station — in particular, the National Science Board approved planning for a 110 person "enhanced" station at an estimated cost of $181 million — these plans were developed in a very different budget environment. NSTC recommends revisiting the issue of the station's ultimate replacement: "The plans will benefit greatly from further cost-benefit analysis that examines the trade-off between the size, lifetime, and capability of the station vs. the anticipated requirements of the science program." In the meantime, several deficiencies in the facilities at the South Pole require immediate attention. "The USAP should give highest priority to correcting critical health, safety, and environmental issues at the current South Pole station." Indeed, $25 million has been requested in FY97 to effect the needed repairs.

Concluding Remarks

This review process has proved valuable to those operating the USAP. It has put the program in a broader scientific context and reestablished the geopolitical factors. It has highlighted the need to continue streamlining the Program to be able to maintain the high level of research and to renew the infrastructure in the constrained fiscal environment that we anticipate in the near future.

We remain committed to working with Congress to advance the Nation's goals in continuing our active and influential presence in Antarctica.

The table below indicates what percentage of a discipline is supported by which research platform.

Table III-1. Percentage of USAP Research Funding by Discipline and Facility

	McMurdo Station and Field Camps	Amundsen-Scott South Pole Station	Palmer Station	Research Vessels
Aeronomy and Astrophysics	40%	58%	2%	0%
Biology and Medicine	39%	0%	30%	31%
Earth Sciences	70%	4%	7%	19%
Glaciology	88%	12%	0%	0%
Ocean and Climate	21%	7%	29%	43%

Table IV-1. USAP funding for science and support, by facility, FY 95

	Operations and Logistics	Science			
Palmer		Research Support	USARP*	Total Science	Totals
Station Operations	1.69				
Facilities Maintenance/Engineering/Construction	0.82				
Logistics	3.56				
Direct Research Support		1.15	4.80		
Total Palmer Station	6.07			5.95	12.02
South Pole Station					
Station Operations	2.25				
Facilities Maintenance/Engineering/ Construction	0.84				
Logistics	2.44				
Direct Research Support		4.25	6.70		
Total South Pole Station	5.54			10.95	16.50
McMurdo and Field Camps					
Station Operations	42.07				
Facilities Maintenance/Engineering/ Construction	4.81				
Logistics	30.68				
Direct Research Support					
McMurdo Station**		2.00	3.315		
Field Camps		17.15	9.945		
Total McMurdo Station	77.55			32.41	109.96
Research Vessels		17.52	4.30	21.82	21.82
Off-Continent Costs	35.53				35.53
Totals	124.69	42.08	29.06	71.14	195.83

*United States Antarctic Research Program: budget line for research grants to institutions

**Nearly all of this amount represents costs of operating the Crary Lab in McMurdo Station.

Chairman SCHIFF. Next is Dr. Sullivan.

STATEMENT OF NEAL SULLIVAN, DIRECTOR, OFFICE OF POLAR PROGRAMS, NATIONAL SCIENCE FOUNDATION

Dr. SULLIVAN. Good afternoon, Mr. Chairman. I am Neal Sullivan, Director of the Office of Polar Programs, and I came to Washington about three years ago after serving as a Professor of Biology and Ocean Sciences at the University of Southern California.

Through that career I did a good bit of work and actually started my work in the Arctic. I worked with the Navy quite a bit on drifting ice stations and moved to the Antarctic where I spent about thirteen years educating ten graduate students in their Ph.D.s and doing research. We were fascinated by the Antarctic as a national laboratory that enabled us to study life, frozen in the ice, that was still active and contributed to the drawndown of carbon dioxide that man puts into the atmosphere—the excess carbon dioxide.

So I've seen firsthand both polar regions, and I was delighted to be able to come to Washington to help lead the National Science Foundation in their effort to do world-class research in both of the polar regions, both the Arctic and the Antarctic.

I would rather confine my testimony today to the NSF's unique role in the Antarctic, as seems appropriate. As Dr. Moniz mentioned with regard to the NSTC report and NSF's role in Antarctica, we have followed the Presidential directive to essentially coordinate and support and manage the U.S. Antarctic Program on behalf of the nation. Our role has been articulated in a series of Presidential decision directives and memoranda dating from about 1970. 1976 was an important one; in 1982 was Presidential Memorandum 6646, having the idea of an active and influential presence; and in 1994 Presidential Decision Directive 26 of the current Administration articulated the importance of our environmental stewardship at both the Arctic and the Antarctic—both poles.

I think a reaffirmation of the important scientific foreign policy and national security interests that serve the United States is contained in the 1996 report by the NSTC, as Dr. Moniz has told us; and I think that report serves us very well for those reasons that he mentioned.

I would like to explain to you and maybe complement some of the information you saw in the movie. I think you clearly know that the conduct of science is the principal activity in Antarctica. The 2,500 who visit Antarctica who are a part of the U.S. Antarctic Program go there because the Antarctic really is a national laboratory. It's an extraordinary continent surrounded by a most unusual and large ocean that connects all of the world's oceans.

We do research and support research in astrophysics and in glaciology, geology, geophysics, oceanography, atmospheric sciences, ecology, biology and even biomedical science. So it's a very diverse program. It's almost a microcosm of the National Science Foundation in the diversity of research that is supported there.

But we don't just support individual programs and, as Dr. Moniz mentioned, we have clearly three major research areas. One is research of large-scale systems because Antarctica is a large continent, as large as the United States and Mexico put together, and there is probably a little bit of space left over. It's ten percent of the Earth's land mass. It covers six percent of the Earth's oceans; and it really provides opportunities for us to gain fundamental knowledge about the Earth and understand global issues, such as continental drift, because the continent was a major part of the large supercontinents, and climate change, as well as ocean circulation and pollution.

Antarctica holds a key to understanding continental drift and plate tectonics because it was such a large component of the supercontinents, and the changes in the region's oceans are a pivotal influence on the world deep-ocean circulation. The waters that sink during the formation of ice around the Antarctic continent on the surface of the ocean, those waters sink to the bottom of the ocean and they come up about eight to thirteen hundred years later off the North Atlantic. So they move the flow of the ocean, and they are critical to rejuvenating with oxygen the deep ocean and allowing life to occur in that area.

Now you know, I'm sure, the research on the Antarctic ozone hole has been supported by many researchers in the U.S. Antarctic Program; and other agencies have done tremendous work in this area, and that led in 1995 to a Nobel Prize in chemistry to Drs. Crutzen, Molina and Rowland for their pioneering work on atmospheric chemistry, fundamental knowledge again that has allowed us an understanding of the world that we live in.

That research is winding down, and what is coming up in its place is, "What is the effect of the increased ultraviolet light that penetrates the Earth's surface as a result of the decrease in ozone, and how does it affect organisms and ecosystems."

But we also do a series of work that is related to the uniqueness of the Antarctic continent. You've probably heard that it's called the coldest, the driest, the highest, the windiest and the most isolated continent on earth. I believe it's also the most beautiful and magnificent continent, but that doesn't have much to do with the science, except it often keeps the scientists who go there engaged for quite a long time until they complete their research.

So we go to Antarctica selecting research that can only be done there or best be accomplished in the Antarctic. If we can do that work better in the Arctic or in another part of the world, it's prudent for us to do that. But it's clear that a place like the South Pole, which is very distant from centers of human population and industry, make it an ideal location to monitor the background composition of the planetary air and the atmosphere; and for 37 years we've monitored—mostly through the NOAA facility there—a 37-year data set of atmospheric carbon dioxide that has wound up slowly, and we can see that it's increasing, a part of the excess CO2 that we put into the atmosphere.

And, at the same time we're looking with the oceanography community at the capacity of the ocean to absorb a large fraction of that CO2. The southern ocean is modeled now, and the calculation is that it may absorb up to 30 percent of the so-called excess CO2 that is put into the atmosphere.

Antarctica is also the source of most of the world's meteorites. They're easy to find there. They accumulate in particular regions, and the meteorites themselves offer clues to the origin of the solar system.

In particular, I think it's the single annual day/night cycle, six months of light and six months of darkness. As a result of that and the particularly unique platform that the South Pole represents, this is the area where the best early developments and results in solar seismology came from. The work supported at the South Pole uses the continuous availability of the sun to get at high-quality data that constrains the solar models that are fundamental to understanding stellar evolution.

Because of the low temperatures at the South Pole and the near absence of water vapor, the skies are consistently clearer and darker than any place else on the Earth, making the geographic South Pole the world's best existing observatory site for infrared and submillimeter astronomy.

These observations help us answer major questions about the formation of the universe, including processes by which stars form and interstellar gases form and the formation of planets and the nature of primeval galaxies and even the distribution of matter and energy in the early universe. So it's an unusual area for that reason as well.

Many of the people continue to come here because they're still exploring the geographic frontier, and it's not exploration as Scott and Amundsen did a hundred years ago, but it's observations like the fact that the polar plateau, this huge glacier that covers the Antarctic Continent, is extensive, it's deep, it's dark and it's remarkably transparent.

You can see through this ice hundreds of meters, and that means that it is potentially one of the great sites for building a cubekilometer array for mapping extraterrestrial neutrino sources because the neutrinos pass all the way through the Earth from outer space, from explosive phenomena in the universe. They pass all the way through the earth, come out through this clear ice, and a set of photomultiplier tubes, in a sense eyes that sit there and look at that ice mass and watch for blue flashes of shirked-off radiation indicating the presence of these neutrinos, possible presence and detection can be done at the South Pole uniquely.

If this experiment is successful, and it's probably the best example I can give you of high-risk, but high-payoff research that we support, we would not only open a new area, but we would actually open up a new field of science that doesn't even exist today. So it is something that we're very proud of.

We also are interested in understanding the stability of the ice cap that covers the Antarctic Continent, particularly the West Antarctic part. If you look back at the continent, the part that would be at about six o'clock to nine o'clock, you realize there is a mass of ice about a mile thick; and, that mass of ice is relatively unstable. Because of warming of the atmosphere, of active volcanoes perhaps that exist beneath that ice, because that ice mass is floating in the ocean, and because there are rapidly moving ice streams in it, it seems to the glaciologists to be unstable; and if it were to collapse on a hundred year or a couple of hundred year time frame, it could raise sea level six meters, 18 feet. This is an area of research that is of fundamental importance, but it has clear implications for society throughout the world.

I could go on and on, and as a professor, I'm inclined to go on and on, but I recognize I have a few more minutes and I would like to talk to you about environmental activities that we have in the program.

Thanks to the Congress, we have undertaken with your help a five-year program to improve waste management in the Antarctic. We had a black eye for the way we managed the waste in the Antarctic during the '70s and the '80s, and if you watch old films on television you can still see that view, but it's a changed view now and it has changed for a number of reasons.

One of those is that we've actually changed human behavior in the participants who work on the continent. You walk through McMurdo, which looks like a mining town, and it's difficult to find a cigarette butt or a loose scrap of paper. But we've also complemented the program in such a way that it has become a model for an exemplary way of managing waste that some small communities in the United States are now looking at. As an example, we have a recycling rate that's 70 percent, more than triple the national average. We're proud of it and we're going to continue to improve that and maybe export it.

In terms of operations and logistics support, I would just like to mention that changes in the operational components of the program are important to us. We're focusing on streamlining the program and its operational logistics cost to realize some efficiencies and to enable a more effective support of the science, which is what we're there to do.

The management strategy that we have in place is to privatize the functions performed by DOD to the extent that it's possible to do that and to increase the efficiency and the economy, but to do that without compromising the health and the safety of program personnel.

We have already privatized the maintenance of the stations' food services and vehicle operations. We're looking to medical facilities, crash and fire, air traffic control and so forth, and that has moved along remarkably well since the Navy stated their plan for withdrawal in 1993. In fact, that was in place before 1993. So it was consistent with the Navy's withdrawal plan. I point out it's not DOD withdrawal, but just the Navy.

In addition to the savings that we anticipate from transferring tasks from the military to the private sector, we also are planning transfers of responsibility within the military, within DOD, and in particular with regard to the C-130 aircraft, the ski-equipped aircraft that you saw in the film. There are only two groups in the United States that handle this small and unique fleet of aircraft, fourteen aircraft. Roughly half of them are maintained and operated by the VXE-6 in Point Mugu, California, and the other half by the Air Force, or the Air National Guard rather, the 109th in Schenectady, New York.

What we see is a movement towards single-point management by the Guard which will consolidate the operation and the maintenance of both of these squadrons under a single DOD manager. That works well for NSF managing the program, and it should work well for DOD management, and for a number of very good reasons.

The most important is we think we can have substantial cost savings because the Air Guard has both an Arctic and an Antarctic mission, and they occur at opposite times of the year. In our winter, the Air Guard can be working in the Antarctic supporting science, and in the our summer they can be in the Arctic preforming both their science mission and their military mission, an important part that I'm sure will be elaborated on by Mr. Pirie's testimony.

In terms of international collaboration, another topic I know you're interested in, I would just like to say that international cooperation is really the hallmark of research. There is a free and open exchange of information by the nations that do work. We have a number of programs, and in my view each nation really pays their fair share of the costs and will continue to.

The last topic that I would like to bring up is South Pole Station. The station is nearing the end of its design life. We have some serious concerns in the health and environmental aspects of the program, and with your help we have put forward in the President's budget a request for $25 million in the MRE account to address the most urgent health and safety issues there. We are very pleased with this, and we know it has moved well in the Congress, and we are anxious to do that. Of the $25 million, $10 million comes from OPP.

Chairman SCHIFF. Dr. Sullivan, I don't normally interrupt a witness, but I just want to say——

Dr. SULLIVAN. I'm going on and on.

Chairman SCHIFF. I wasn't going to say that yet because I appreciate your testimony. I was going to say I believe we've gotten the $25 million. It was authorized by this Committee and I believe it's contained in the Appropriations Bill.

Dr. SULLIVAN. Yes, it is.

Chairman SCHIFF. I appreciate your support of it and the Administration's support, but I just wanted at this point to mention for the record since you brought it up, that it looks very good for us getting that $25 million. Excuse my interruption.

Dr. SULLIVAN. Thank you very much and we really appreciate your help.

Let me just finish by quickly saying that the NSTC report asked NSF to form a panel, and we have begun that process. Our Director, Neal Lane, has worked with Mr. Norman Augustine, CEA, Chief Operating Officer and Vice President of Lockheed-Martin. He has accepted that charge, and he is planning on providing a report early in the new year, a final report, and perhaps a letter report as early as December, which might inform the 1998 budget process in some of the areas that are of importance to us and of importance to the Committee.

Thank you for your long patience. I will end. Let me just say my favorite quote in the three years I've been here comes from Guy Stevers, who is a former Director of the National Science Foundation, the first Director to go to the South Pole. After hearing a two-day brief, he said, "The U.S. Antarctic Program is good for science and good for the nation." I believe that, and with that closing remark I thank you very much.

Chairman SCHIFF. I appreciate your testimony very much. We are right now working on the street where you live. So I do appreciate the contribution of your expertise.

[The prepared statement of Dr. Sullivan follows:]

Testimony of

Dr. Neal Sullivan

Director, Office of Polar Programs

National Science Foundation

Before the

House Science Committee

July 23, 1996

Mr. Chairman, I am Neal Sullivan, Director of the Office of Polar Programs at the National Science Foundation, and I appreciate the opportunity to talk about the U.S. Antarctic Program.

NSF supports world-class research at both poles. I will, however, confine my testimony today to NSF's unique role in the Antarctic. Since 1976, NSF has been the agency responsible for single point management of the United States Antarctic Program. In 1982, the President reaffirmed in Presidential Memorandum 6646 the national policy underlying the USAP and directed that the Program be maintained at a level providing an active and influential presence in Antarctica. This policy was amended with Presidential Decision Directive 26 which articulated the importance of environmental stewardship at both poles.

Since the first statement of U.S. policy in Antarctica in 1970, NSF has been the federal agency responsible for coordinating and supporting all U.S. government sponsored activities, including adherence to the Antarctic Treaty which guarantees freedom for scientific research and prohibits military and nuclear activities there. A reaffirmation of the important scientific, foreign policy, and national security interests served by the United States Antarctic Program is contained in the study by the National Science and Technology Council.

As you know, the conduct of science is the principal human activity in Antarctica. The continent and the seas around it are a natural laboratory in which to investigate fundamental questions in astronomy and astrophysics, glaciology, geology, geophysics, oceanography, the atmospheric sciences, ecology, biology, and biomedical science. Insights from these disciplines provide new knowledge, with global implications. The harsh, desolate, and remote land areas provide unparalleled research analogs for other planets.

Research on Large Scale Systems

Antarctica and its surrounding oceans - 10% of Earth's land mass and 6% of its oceans - provide major opportunities for research to expand fundamental knowledge of the region and to help us understand global issues such as continental drift, climate change, ocean circulation, and pollution. Antarctica holds a key to understanding continental drift and plate tectonics because it was a major component of several supercontinents. Changes in the region's oceans are a pivotal influence on the world deep ocean circulation and biotic productivity. Isolation from industrial centers has made the region ideal for measuring natural variability of the atmosphere and anthropogenic impacts on it. The continental ice sheet volume and the seasonal variation in sea ice extend beyond the continent to influence atmospheric and oceanic circulation around Antarctica. Human-caused increases of greenhouse gases (e.g., CO2 , chlorofluorocarbons, and methane) may have profound effects in the region, where models predict greater change than in temperate latitudes.

Recent research on the significant reduction of stratospheric ozone over Antarctica each spring has aroused international attention. Data collected in Antarctica show that atmospheric chemistry processes, stimulated especially by the buildup of artificial chlorofluorocarbons (CFCs), is destroying the ozone. One consequence of a decrease in ozone is an increase in the amount of ultraviolet radiation reaching Earth, which if sustained could cause skin cancer, cataracts, and immune system damage to higher animals, including humans.

Research on the Antarctic ozone hole by many researchers supported by the USAP and other agencies led to award of the 1995 Nobel Prize in Chemistry to Paul Crutzen, Mario Molina, and F. Sherwood Rowland, for their pioneering work in atmospheric chemistry, particularly concerning the formation and decomposition of ozone. Collaborative, interagency research has explained the fluorocarbon cause of the ozone hole, and future work will monitor the magnitude of the phenomenon.

Research Unique to the Antarctic

Antarctica is the coldest, driest, highest, windiest and most isolated continent on Earth, and as a result Antarctica is an expensive and difficult place to do research. However, these unique conditions also provide the opportunity to do research that can be only or best accomplished in the Antarctic.

The South Pole's distance from centers of human population and industry make it an ideal location to monitor the background composition of the planetary atmosphere. For example, the station has an unbroken 37-year data set of atmospheric CO2.

Antarctica is the source of most of the world's meteorites, which offer clues to the origin of the solar system. While most meteorites originate in the asteroid belt, a few of the Antarctic samples found by the USAP have been confirmed as being from Mars. Some of these meteorites reflect the presence of water on Mars, adding to speculation about the existence of life there.

The single annual day-night cycle at the geographic South Pole allows continuous observations of the skies for long uninterrupted periods. The best early developments and results in solar seismology came from USAP-supported work at the South Pole and used the continuous availability of the sun to get high-quality data that constrained solar models fundamental to stellar evolution.

Because of the low temperatures and the near absence of water vapor in the atmosphere above the polar plateau, the infrared skies are consistently clearer and darker than anywhere else on Earth, making the geographic South Pole the world's best existing observatory site for infrared and submillimeter astronomy. Observations at very low frequencies in the electromagnetic spectrum have the potential for answering major questions about the formation of the universe, including the processes by which stars form from interstellar gas, the formation of planets, the nature of primeval galaxies, and the distribution of matter and energy in the early universe.

Exploration of the Geographical Frontier

The polar plateau is an extensive, deep and dark, but remarkably transparent ice sheet that appears to be ideal to support the installation of a muon and neutrino detector array for mapping extraterrestrial neutrino sources. This recently recognized feature of the ice sheet will open new opportunities in neutrino astrophysics, offering insight into the high energy physics of the most explosive phenomena in the Universe.

Because Antarctica contains almost 10% of Earth's continental crust, it has substantial geologic records of plate tectonic processes, evolution and dispersal of life, and evidence of past environmental conditions at Earth's surface. Studying the records provided by this crust is necessary for a balanced picture of Earth's geologic development. Using aerogeophysics to sense the crust underneath the west Antarctic has led to the discovery of volcanoes, which may themselves be melting the ice and lubricating its base to quicken its flow into the ocean.

West Antarctica contains rifted, and therefore thinned, continental crust beneath the world's last marine-based ice sheet. Consequently, this region is the most important region in the world for understanding the possibilities of future sea level change. The discovery of ice streams within the west Antarctic Ice Sheet has led to an understanding of glacial flow and the potential for ice sheet collapse.

Antarctica has been in a near polar position for the last 100 million years, so the South Polar region contains records of climate and environmental change over a long period. The inference of a mild climate, indicated by beech tree fossils close to the South Pole as recently as two million years ago, cannot be reconciled with currently understood polar processes.

Environmental Activities

Let me also provide some background on NSF's recent environmental activities in the Antarctic. In 1990, Congress asked NSF to undertake a 5-year program to improve waste management in the Antarctic. We completed that program last year and in so doing, we have not only achieved compliance with the Antarctic protocol, we have established exemplary waste management procedures.

For example, we have a recycling rate above 70 percent, more than triple the national average. Every decision by NSF to acquire an item and ship it to Antarctica begins with an analysis of the implications for waste disposal. Not only has this made environmental protection more central to our operations, it has made our logistics more efficient than before.

Operations and Logistics Support

I would like to also mention changes in the operational components of the Program. Present management objectives have focused on streamlining the Program's operational and logistics costs to realize efficiencies and enable more effective support of science. The management strategy is to privatize the functions performed by the DoD to the extent possible, whenever it leads to increased efficiency or economy without compromising health or safety. These privatization efforts will include activities such as station maintenance, food services, and vehicle operations and repair. This objective received added impetus with the Navy's plan, stated in 1993, to withdraw from the U.S. Antarctic Program.

In addition to the savings anticipated by transferring tasks from the military to the private sector, specific transfers of responsibility within the military can also provide appreciable cost savings. The snow ski-equipped C-130 (LC-130) is the only aircraft of its type in the world. There are only two operators of the LC-130, a Navy squadron based in Pt. Mugu, CA (VXE-6), and an Air National Guard wing based at Stratton Air National Guard Base in Schenectady, NY (109th AW). VXE-6 operates and maintains NSF's fleet of LC-130s. Single Point Management by the Guard will consolidate the operation and maintenance of these two squadrons under a single DoD manager to meet Arctic and Antarctic logistics and science support requirements.

Single point management of these airplanes will reduce costs by eliminating duplicate organizations at all levels, reducing personnel and training costs, standardizing equipment and maintenance and operating procedures, and streamlining the planning and scheduling of polar airlift. The USAP will reimburse the Air Force only for its support to the Antarctic program.

International Collaboration

International collaboration is a hallmark of Antarctic research. There is free and open exchange of information, and stations and facilities are generally available for international programs ranging in scale from collaborations between individual scientists, to the sharing of national resources to support larger scale programs. These interactions are encouraged through a variety of international forum ranging from the Scientific Committee on Antarctic Research (SCAR) of the International Council of Scientific Unions, the annual Antarctic Treaty Consultative meetings, the Council of Manager of National Antarctic Program and their Standing Committee on Antarctic Logistics and Operations. These opportunities permit National program objectives to be discussed and compared. Where objectives in research or logistics overlap, opportunities for cooperation are discussed.

There are several prominent examples of U.S. cooperation with international partners. Some examples include the exchange of logistics resources between the U.S. and New Zealand, and the U.S. and Italian national programs. The scientific and logistic collaboration among the U.S., French, and Russian programs to obtain the deepest ice core from Vostok station, and similar collaboration among the U.S., New Zealand, Italian, U.K., Germany and Australia programs to obtain 4 ocean sediments cores in the vicinity of Cape Roberts, Antarctica, demonstrate the potential for continued international cooperation.

South Pole Station

One area of the USAP which has received considerable attention is the U.S.

station at the South Pole. The majority of the existing facilities at Amundsen-Scott South Pole Station were constructed in the early 1970s and were first occupied in 1974. The station was designed to support a science program significantly smaller and less sophisticated than that supported today. The station uses 30-year-old construction (pre-dating subsequently recognized environmental concerns), and supports 140 people during the summer months, the majority housed in temporary facilities. Some of the permanent facilities have been upgraded since the 1970s, but most of the structures lack the engineered safety features now standard in the United States.

The general approach taken to upgrade facilities to address safety and health concerns at the U.S. Antarctic stations is to use U.S. standards, adapted to the sometimes unique program conditions. The operational philosophy is one of "managed risk" -- minimizing exposure to hazards. Protection of life and health is the highest priority. Protection of property is the second priority. Risks are minimized to the extent that life, health, and property are protected. If risks reached a point that life of personnel were endangered, facilities would be closed.

As the infrastructure ages, it becomes increasingly costly to maintain activities. With level budgets, the cost of risk management increases at the expense of other program costs, including direct science support. The station at the South Pole currently has in place a continuous monitoring system to compensate for inadequate ventilation in the garage and shops. When air quality deteriorates to unsafe levels, administrative controls reduce personnel exposure. The side effect is that work in the garage and shops stops until air quality is safe. A temporary exhaust system will be installed as an additional interim measure next season. The current power plant has a backup system which will support life should the main generators fail. There are two external fuel tanks (outside the station) which would provide additional fuel to the station in an emergency.

To address the most significant safety and environmental concerns at the South Pole, several specific improvements, totaling $25 million, were included in the FY97 budget request as part of NSF's Major Research Equipment (MRE) request. The three areas are the heavy equipment maintenance facility, the power plant, and fuel storage. The current garage and shop areas have code and safety deficiencies that pose health and safety risks for personnel. These deficiencies are being addressed through administrative and management procedures that make operations safe. These procedures, however, have a cost to implement and an impact on operational efficiency. Administrative controls have been implemented to reduce safety risks to scientists and operational personnel. The garage/shop upgrade would address: (1) the absence of exhaust ventilation systems capable of maintaining hazardous airborne contaminants to within acceptable levels, (2) lack of fire suppression systems in an area where presence of fuels, lubricants and other flammable materials is required, and where ignition sources are present, (3) minimal facilities and equipment for working on the large heavy industrial vehicles used at South Pole Station, and (4) severely limited space requiring the scheduling of projects to avoid work conflicts between the trades.

The Power Plant is the backbone of the Station, providing basic life support in the form of electricity and heat. It represents a potential "single point failure" for continuation of the science program. The current power plant is operating at capacity, resulting in brown-outs. It has electrical and operational deficiencies that restrict operations. The existing three 350kw generators are relatively fuel inefficient, and the 20-25 year old power plant structure is overcrowded. Emergency power is for minimal life support systems only. The power upgrade would include new housing for the equipment, new higher capacity generators, new switch gear, transformers, power conditions, fire suppression equipment, water treatment and water storage for the station. Storage for up to 300,000 gallons of fuel is required at the South Pole. Fuel is currently stored in fuel bladders, without secondary containment, that have risk of leakage or major spills. Steel storage tanks are needed to meet minimum environmental standards. Their capacity will also help to meet fuel demands for increased electrical requirements. The fuel storage upgrade includes 10,000-gallon steel tanks with secondary containment for all tanks and fuel piping and pumping system.

As you are aware, one of the recommendations of the NSTC Report was the establishment of an external review panel to further consider certain aspects of the U.S. Antarctic Program. I am happy to report that we have begun that task. We now have a chairman, Dr. Norman Augustine of Lockheed-Martin, and are in the process of recruiting panel members. The chairman has already expressed his plans to have a final report completed by early in 1997.

Mr. Chairman, thank you again for this opportunity to provide information on the U.S. Antarctic Program. Let me conclude by expressing my appreciation to members of this committee for the interest shown in our Program. NSF's support of research in the Antarctic has been shaped by history, geography, diverse federal agency roles, logistics consideration, and scientific opportunities. In the final analysis, however, our programs are driven by ideas from the research community, and we at NSF will continue our efforts to address the important scientific questions that can be studied in and around the unique Antarctic continent.

Chairman SCHIFF. Mr. Scully.

STATEMENT OF R. TUCKER SCULLY, DIRECTOR OF THE OFFICE OF OCEANS AFFAIRS, DEPARTMENT OF STATE

Mr. SCULLY. Thank you very much, Mr. Chairman. I'm delighted to be here to participate in these discussions on the future of a very important U.S. program.

Let me start also by expressing our appreciation for the initiative taken by the Science Committee in introducing and securing passage of H.R. 3060, the Antarctic Environmental Protection Act of 1996, a bill to implement the new Antarctic Environmental Protocol. This bill will enable the United States to become a party to the Protocol, an objective which is a major priority of U.S. policy. We are among the few countries that remain to ratify the Protocol and whose ratifications are necessary to bring it into force. We're very hopeful that the same bipartisan spirit that animated the House will also move the Senate to act promptly so that the bill can be rapidly enacted into law, and again we salute the Committee for taking this initiative.

Chairman SCHIFF. Once again I apologize for the second time in interrupting a witness. I don't normally do this, but if you've found a way to get the Senate to move quickly on anything I sure wish you would share it with us.

[Laughter.]

Mr. SCULLY. We're doing everything we can, Mr. Chairman, and hope we can help you form an alliance on that point.

Here my basic message is, and I think these points have been alluded to by both Dr. Moniz and Dr. Sullivan, but the basic point from the State Department's perspective is that the U.S. Antarctic Program is a national program that serves important foreign policy and national security objectives, as well as basic scientific and environmental objectives. And, from this perspective we believe that maintaining our active and influential presence of the United States in Antarctica, including the renovation and continued occupation of South Pole Station, represents a priority and a cost-effective investment in the national interest. So that is our basic message.

I should note that the U.S. commitment to an active and influential presence in Antarctica has been a fundamental component of U.S. Antarctic policy ever since we've had an Antarctic policy, and that the U.S. policy towards Antarctica has represented really, if one looks at it over the past four decades, it represents a very high and remarkable degree of continuity, a continuity that was most recently reaffirmed in the endorsement of the importance of Antarctica for United States national interests in Presidential Decision Directive 26 of June 9, 1994 that I think has also been alluded to.

Our interests in Antarctica are given concrete expression through the Antarctic Treaty of 1959, and I'll come back a bit to the provisions of the Treaty. Basically the Treaty guarantees freedom of scientific research in Antarctica and prohibits military and nuclear activities in the area, including rights of on-site inspection to ensure that parties comply with the Treaty.

The Treaty had provided the framework for the successful pursuit by the United States of the opportunities that Antarctica offers for scientific research as well as associated goals of protecting its environment and conserving its living resources.

Moreover, the Treaty is noted as a key arms control agreement and a conflict-avoidance mechanism. The framework for managing disputes, potential disputes over territorial sovereignty in Antarctica that the treaty provides has prevented regional conflicts, such as the war in the Falkland Malvinas Islands or disputes over the Beagle Channel, from spreading to Antarctica. The United States, we believe, has a major interest in the international peace and stability in the area that results from the successful operation of the Antarctic Treaty.

Now in our view also, the success of the Treaty and the achievement of U.S. interests through the Treaty derive directly from the year-round presence, the active and influential presence in Antarctica that is maintained by the U.S. Antarctic Program, the program including its scientific research activities and its associated logistics and support activities that are managed and funded as a single program by the National Science Foundation. And we would note that the most visible symbol of this presence is the U.S. presence at South Pole Station, the area which has been in continuous occupation since the 1950s, the area where all the claims that have been made to territorial sovereignty in Antarctica intersect.

Turning to that particular issue, let me step back a minute, Mr. Chairman, to the genesis of the Antarctic Treaty itself. When scientific research interests in Antarctica began to become a major focus for the international scientific community in the 1950s, scientific activities in Antarctica necessitated dealing with the potentially explosive disputes over territorial sovereignty in Antarctica.

Seven nations, all of them now allies of the United States—Argentina, Australia, Chile, France, New Zealand, Norway and the United Kingdom—all of them had asserted by that time claims to territorial sovereignty over parts of Antarctica. Some of those claims overlapped and conflicted among themselves. Argentina, Chile and the U.K. all claimed basically the same piece of Antarctica, and there was an area that was unclaimed. The United States, the Soviet Union and other nations that were active in science in Antarctica did not recognize these claims. This was in spite of the fact for the United States that we had clearly established the basis of the claim to most, if not all, of the continent.

Americans had been involved in the first voyages to Antarctica in the early 19th century, and our leadership in exploration of Antarctica, beginning with Admiral Byrd's expeditions prior to World War II, had made the United States the preeminent nation on the continent in this period of the mid-1950s.

Nonetheless, and I think this was quite a far-sighted decision, the United States decided that its interests in Antarctica were best served by not making a claim to sovereignty even though, as I mentioned, we probably had one of the best claims and a claim perhaps that would extend to the entire continent.

We defined our basic objectives rather, as preserving the rights for U.S. nationals of free access for peaceful purposes to all areas of Antarctica, particularly for scientific research, and defined our interests as the removal of the disputes over territorial sovereignty as the source of conflict with respect to this important area of the world.

This was the basis for the initiative the United States took and, as I think has been mentioned, it derived from the scientists themselves, but the United States took the initiative in 1958/59 to negotiate a treaty that would serve these objectives, the objectives of preserving Antarctica as a place for science and removing it as a source of international dispute.

The result of that initiative was the Antarctic Treaty of 1959, sometimes called the Washington Treaty. The Treaty as noted guarantees freedom of scientific research throughout Antarctica, reserves the area exclusively for peaceful purposes, including a prohibition on all activities of a military nature, nuclear testing and nuclear explosions, and establishes a system of governance, if you will, regular meetings among parties to the Treaty to develop measures to implement its provisions and to deal with new circumstances and new situations.

A central feature of the Antarctic Treaty and the features that basically make it work are its imaginative provisions on the juridical issues and on decision-making. Basically these provisions permit the parties to agree to disagree over the sovereignty question.

It prohibits new claims to sovereignty and provides that no acts or activities carried out while the Treaty is in force shall constitute a basis for a claim to territorial sovereignty and protects the positions of those who had previously asserted and those who had rejected claims to sovereignty, including protecting bases of claims, such as those that the United States has.

In addition, with respect to decision-making, the Treaty operates by consensus, and I think this point, an important point with respect to our presence in Antarctica, links decision-making competence under the Treaty to activities in Antarctica. The Treaty itself was negotiated among the original twelve parties to the Treaty with those who were originally active in scientific research in Antarctica, and full decision-making rights under the Treaty are linked to the actual involvement in some concrete activities—concrete scientific activities in Antarctica. In other words, if you wish to be a major player, you need to be involved in activities on the ice.

The Treaty has proven to be one of the most effective, durable and dynamic international treaty mechanisms that has emerged since the Second World War. It has provided an effective basis for dealing with new circumstances, for accommodating new players, and for developing new important environmental scientific resource management arrangements. Again I would note the new Environmental Protocol to the Antarctic Treaty as an example of that.

In addition, the number of parties active in Antarctica have grown from twelve in 1959 to 26, and they include all permanent members of the U.N. Security Council, major countries such as Japan, and developing countries such as India, Brazil and China.

The regular meetings of the Treaty parties have provided a forum for peaceful cooperation among these parties, among these nations even when relations otherwise among them are strained or hostile. The example of the U.K. and Argentina continuing to meet during the War over the Falkland Malvinas is an example, and the ability of the United States and the Soviet Union to cooperate even during the height of the Cold War is another.

More than any other nation, the United States benefits from the Antarctic Treaty. The potential for international conflict and for international discord in this part of the world that would exist in the absence of the Treaty is in our view, if anything, greater now than it was in 1959. The United States has developed, within the framework of the Treaty, a world-class program of scientific research, of which you've heard a good deal already in our testimonies; and the Treaty has shaped innovative resource management arrangements for living resources and innovative environmental agreements, again as illustrated in the new Environmental Protocol.

In our view, the effective operation of the Antarctic Treaty is a direct result of the active and influential presence that the United States maintains and has maintained in Antarctica. This presence accords us, in our view, a decisive role within the Treaty's activities based decision-making system and in maintaining the legal and political balance between claimants and non-claimants that makes the Treaty work.

In conclusion, Mr. Chairman, from our perspective it is essential for us to continue to maintain an active and influential presence in Antarctica, including the year-round presence at South Pole Station. This presence demonstrates our commitment to assert its rights in Antarctica, our basis of claim and our commitment to conducting the cutting-edge scientific research there. The U.S. presence as maintained in the U.S. Antarctic Program is the basis for our leadership within the Antarctic Treaty and within its system of governance.

And to reiterate the basic point that we started with, it is our view that the maintenance of such presence in Antarctica, again including the renovation of South Pole Station, represents a very important priority for the United States from the foreign policy perspective as well as from the scientific perspective and represents a very cost-effective investment in the overall U.S. national interest.

Thank you.

[The prepared statement of Mr. Scully follows:]

TESTIMONY OF

R. TUCKER SCULLY
DIRECTOR OF THE OFFICE OF OCEAN AFFAIRS
DEPARTMENT OF STATE

BEFORE THE

SUBCOMMITTEE ON BASIC RESEARCH
COMMITTEE ON SCIENCE
UNITED STATES HOUSE OF REPRESENTATIVES
23 JULY 1996

Mr. Chairman:

I am pleased to appear at this hearing of the House Committee on Science to discuss the future of the U.S. Antarctic Program.

The United States has important national interests, including foreign policy and national security, in Antarctica. These include:

- maintenance of Antarctica as an area of peaceful international cooperation, to which U.S. nationals have access for peaceful purposes.

- pursuit of the unique opportunities Antarctica offers as a laboratory for basic scientific research - research which provides insights essential to the understanding of our planet;
- protection of the Antarctic environment and conservation of its living resources; and
- preservation of the U.S. position of non-recognition of claims to territorial sovereignty in Antarctica.

United States interests are given concrete expression through the Antarctic Treaty of 1959. The Treaty guarantees freedom of scientific research in Antarctica and prohibits military and nuclear activities.

The primary expression of these interests in Antarctica is the year-round presence there maintained by the United States Antarctic Program (USAP), the program of scientific research and associated logistics funded and managed by the National Science Foundation. This presence includes continuous operation of a stationat the South Pole that the U.S. has operated since 1957 at the summit of the Antarctic ice cap, as well as two other strategically located stations.

Current United States Antarctica policy dates from the 1950's when growing scientific research activities in Antarctica necessitated coming to grips with potentially explosive disputes over territorial sovereignty there. Seven nations (Argentina, Australia, Chile, France, New Zealand, Norway and the U.K.) had asserted claims to territorial sovereignty over parts of Antarctica. The claims of Argentina, Chile and the U.K. overlapped in the Antarctic Peninsula and one area was unclaimed. The United States, the Soviet Union and other nations active in scientific activities did not recognize these claims.

The United States took the initiative to pursue a treaty among the nations active in Antarctica that would achieve U.S. objectives. The result was the Antarctic Treaty of 1959, or Treaty of Washington as it is often known. The Treaty:

- guarantees freedom of scientific research in Antarctica;

- reserves Antarctica exclusively for peaceful purposes, including prohibition of all activities of a military nature, nuclear testing and nuclear explosions, with rights of on site inspection to ensure compliance; and

- establishes regular meetings of the Parties to develop measures to implement the Treaty and to deal with new issues as they arise.

These provisions rest upon the Treaty's imaginative juridical and decision-making formulations. The Treaty freezes previously asserted rights and claims to territorial sovereignty in Antarctica, as well as any prior basis of claim (e.g., the United States basis of claim). It prohibits any new claims, and provides that no acts or activities carried out while the Treaty is in force will constitute a basis for a claim. Concomitantly, decision-making authority under the Treaty is conditioned upon involvement in actual activities in Antarctica. Specifically, full participation in decision-making rests upon an activities criterion: demonstration of interest in Antarctica by the conduct of substantial scientific research there.

The influence of a Party to the Treaty is directly linked to the extent and quality of its scientific presence in Antarctica. The U.S. Antarctic Program, as it has been carried out for the last 35 years, accords us the leadership role in Antarctica and the Treaty operations. Our leadership role is symbolized in the strategic location of the U.S. South Pole Station at the intersection point of the various conflicting international territorial claims.

The legal and political framework of the Treaty permits Parties to agree to disagree over sovereignty while enabling them - starting from different legal assumptions - to apply common obligations to activities in Antarctica. The Treaty has proven to be a durable and dynamic international framework that has evolved to deal effectively with new scientific, environmental and resource management issues and to accommodate new players. The number of Treaty Parties active in Antarctica has grown from 12 in 1961 to 26 in 1996 and includes all permanent members of the UN Security Council as well as Japan, India and Brazil. The regular meetings of the Treaty Parties provide a forum for peaceful cooperation among them even when bilateral relations are strained or hostile. For example, Argentina and the UK continued to interact peacefully within this forum during the Falklands War and the United States and the former Soviet Union were able to cooperate on Antarctic matters even when relations were at their worst.

The international peace and political stability established in Antarctica by the Antarctic Treaty has been and remains indispensable for successful pursuit by the United States of its Antarctic interests and has become an important objective in its own right.

For all of these reasons, maintenance of health of the Treaty is an important foreign policy and national security objective of the United States. It may seem ironic to apply a national security yardstick, with its military connotations, to an area that is effectively de-militarized. However, the potential for international discord and conflict over Antarctica territorial claims which would exist absent the Treaty is, if anything greater, than was the case in 1959.

More than any other nation, the United States, as the pre-eminent actor in Antarctica, benefits from the effective operation of the Antarctic Treaty. More than any other nation, the United States is responsible for the effective operation of the Antarctic Treaty. This leadership role is founded upon the active and influential presence in Antarctica maintained by the United States through the United States Antarctic Program. This presence accords the United States a decisive role in the Treaty's activities based decision system and in maintaining the political and legal balance that makes the Treaty work.

The Department of State believes it essential that the United States continue maintain an active and influential presence in Antarctica. The United States presence at the South Pole Station demonstrates United States commitment to conduct cutting edge scientific research there. Abandonment of the Station would create a vacuum and likely result in a scramble to occupy the site, to the detriment of our position as well as to the stability of the Treaty system.

The Department believes that funding decisions on the United States Antarctic Program should be based on the fact that it is a national program that serves important U.S. foreign policy and national security objectives as well as basic scientific, environmental and economic interests. From this perspective, appropriation of the funds necessary to maintain an active and influential United States presence in Antarctica represents both a priority and cost effective investment.

The State Department believes that our foreign policy and national interests must be reflected in budgetary decisions affecting United States presence in Antarctica. This concludes my statement, Mr. Chairman, I will be happy to take any questions that you may have.

Thank you.

Chairman SCHIFF. Thank you, Mr. Scully.
Mr. Pirie.

STATEMENT OF THE HONORABLE ROBERT B. PIRIE, JR., ASSISTANT SECRETARY OF THE NAVY (INSTALLATIONS AND ENVIRONMENT) DEPARTMENT OF DEFENSE

Mr. PIRIE. Thank you, Mr. Chairman. I appreciate the opportunity to speak to you today about DOD's support to the United States Antarctic Program. I'm the Senior Manager responsible for ensuring Navy's support for the program as well as the Executive Agent for the Department of Defense's overall support.

The Navy has an illustrious place in the history of the Antarctic. Admiral Richard Byrd began a series of four expeditions to Antarctica in 1928, which included his famous overflight of the South Pole in 1929. The Navy began its post World War II involvement in Antarctica in 1946 with Operation Highjump, the largest expedition to ever explore the continent and surrounding waters, and it involved more than 4,700 Navy and Marine Corps personnel.

The United States participated fully in the 1957 International Geophysical Year's Antarctic Programs, and following that, the Navy established a year-round presence on the ice in support of a permanent science program. The Navy has provided logistic support since then. The Antarctic Treaty signed in 1959 prohibits military activities on the continent and reserves Antarctica for science and other peaceful purposes, but it does allow the military to support peaceful scientific studies.

A White House memorandum in 1982 formalized this arrangement directing the Departments of Defense and Transportation to provide logistic support to the National Science Foundation on a cost-reimbursable basis. For years the Navy has dedicated as many as 850 people to provide a full range of ground and air support to the U.S. Antarctic Program, including public works, waste disposal, food services, supply and air logistics.

Given this long and proud history of supporting the science program in Antarctica, it was with real reluctance that the Navy began to consider withdrawing from this operation in the late 1980s and early '90s. However, the same 1982 White House memorandum that directed the DOD and the DOT to provide logistic support to the NSF in the Antarctic also directed NSF to use commercial support and management facilities where these were determined to be cost-effective. And the post-Cold War drawdown for funding for ships, aircraft and other weapon systems had driven the Navy to focus its assets on core military requirements and to reduce or eliminate non-essential missions.

Despite reimbursement, people used for the Antarctic logistic support count against Navy's military manpower ceiling and are thus not available for manning Navy ships and aircraft. And, finally, the National Science Foundation is impelled to get the most for its research dollar by reducing the cost of support services wherever possible.

The Navy began discussions with NSF in early 1993 to examine alternatives to Navy support. As a result, helicopter operations and most of the ground activities have already been transferred to private contractors. The last piece to be dealt with was the operation of ski-equipped LC-130 aircraft, which are the backbone of logistic support to NSF on the ice.

Since there is by far no commercial capability anywhere in the world that can provide the kind of ski-equipped aircraft capacity required in Antarctica, the Navy and National Science Foundation considered a number of government agencies, Coast Guard, NOAA and the Air National Guard for possible transfer of the LC-130 operations.

The Air Force, the Navy and NSF agree that transfer of this function to the Air National Guard has many advantages.

—The Guard has a core wartime mission for flight support in polar regions, while the Navy does not.

—The Guard has a robust infrastructure to train, maintain and fly C-130s and already flies ski-equipped LC-130s for the Arctic missions. They have also been augmenting Navy flights in the Antarctic since 1988. The Navy's only active duty LC-130 squadron is the one supporting NSF in Antarctica.

—The Arctic and Antarctic missions can be supported during opposite seasons by the same aircraft, personnel and infrastructure with relatively small enhancement to the current Air National Guard levels.

—The merging of Arctic and Antarctic missions in one organization also decreases the reimbursable personnel costs for NSF. Fewer dedicated future military billets are required, and part-time Reserve personnel in Antarctica are paid only while on active duty.

The transition provides the opportunity to defer procurement of new NSF aircraft, avoiding a cost of roughly $350 million. If the Navy had maintained the LC-130 mission, the NSF would have had to replace the entire fleet within probably the next six years. Instead, NSF and the Air National Guard are pursuing upgrading in existing NSF aircraft to be compatible with the Air National Guard aircraft also being upgraded.

Combining upgraded NSF aircraft with new Guard aircraft into a standardized, larger fleet will simplify training, maintenance and scheduling, improve safety, spread flight hours over more airframes and extend service life of the fleet well into the next century. The NSF and the Air National Guard are working out the specifics of this upgrade.

Navy, Air National Guard and NSF have a three-year phased transition plan for the LC-130 aircraft that began in March of this year. The Air National Guard has previously flown about eleven percent of the total flight hours in their augmentation role to the Navy. As part of the three-year transition, the Guard will increase its share of flight hours to 22 percent in this year, 44 percent next year and 70 percent in the third year as the Navy flight hours phase down. The transition will be completed by March 1999 when the Navy's role in the U.S. Antarctic Program will come to a close and our support squadron, VXE-6, will be disestablished.

In January of this year I visited Antarctica to get a full understanding of the complexities of the mission. I am well aware of the safety issues involved. I have asked Admiral Tobin, Oceanographer of the Navy, to visit Antarctica this season to observe firsthand for himself Navy, Air National Guard and commercial operations to ensure that the transition is proceeding smoothly, and that the transition ensures the full safety of crew, passengers, aircraft and equipment.

Mr. Chairman, we are convinced that replacing Navy support to the Antarctic Program with a mix of private contractors and the Air National Guard is a very sound approach with savings to the Department of Defense and the National Science Foundation. I am confident that the Air National Guard can do the Antarctic air logistic job and do it well. The Department of Defense is committed to ensuring a seamless transition of functions with no impact on the science and the safety of the U.S. Antarctic Program.

That concludes my statement, sir.

[The prepared statement of Mr. Pirie follows:]

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RELEASED BY THE
U. S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE

STATEMENT OF

HONORABLE ROBERT B. PIRIE, JR.

ASSISTANT SECRETARY OF THE NAVY

(INSTALLATIONS AND ENVIRONMENT)

BEFORE THE

SUBCOMMITTEE ON BASIC RESEARCH

OF THE

COMMITTEE ON SCIENCE

U. S. HOUSE OF REPRESENTATIVES

ON

"THE FUTURE OF ANTARCTIC RESEARCH"

23 JULY 1996

NOT FOR PUBLICATION UNTIL
RELEASED BY THE
U. S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE

THE HONORABLE ROBERT B. PIRIE, JR.

Mr. Pirie was confirmed by the U.S. Senate as Assistant Secretary of the Navy (Installations and Environment) on 15 March, 1994. He has over thirty years experience in defense-related work in the armed forces, the civil service and in industry. A Naval Academy graduate in the class of 1955, he was also a Rhodes Scholar, and attended Oxford University from 1956 to 1959. He served twenty years as a naval officer, culminating his service with three years in command of a nuclear attack submarine.

Upon retirement from the Navy in 1975 Mr. Pirie joined the newly formed Congressional Budget Office as Deputy Assistant Director, National Security. In 1977 Mr. Pirie became Principal Deputy Assistant Secretary of Defense (Manpower, Reserve Affairs and Logistics). He was nominated to be Assistant Secretary of Defense (Manpower, Reserve Affairs and Logistics) by President Carter in December, 1978, and served in that position until January, 1981. After leaving government service he held a variety of positions in the private sector, including that of President of Essex Corporation and Vice President of the Center for Naval Analyses and Vice President of the Institute for Defense Analyses. He also directed the CNO Strategic Studies Group from 1989 to 1992.

Mr. Pirie and his wife, the former Joan Adams of Barrington, Rhode Island, reside in Bethesda, Maryland. They have three grown children: two sons, John and Carl, and a daughter, Susan.

Mr. Chairman and Members of the Committee, I am Robert B. Pirie, Jr., Assistant Secretary of the Navy for Installations and Environment. I appreciate the opportunity to speak to you today about the transition of logistic functions from the U. S. Navy to the Air National Guard in support of the United States Antarctic Program. I am the senior manager responsible for ensuring Navy support for the U. S. Antarctic Program, as well as the executive agent for the Department of Defense's overall support of the U. S. Antarctic Program.

Let me start with some background on the Navy's long-standing involvement in Antarctica, and the role that other Department of Defense organizations play. I will then explain why we are phasing out our logistic support, and how we are implementing transition plans developed in close coordination with other organizations in the Department of Defense and the National Science Foundation.

The U. S. Navy in the Antarctic

The U. S. Navy began its post-World War II involvement in Antarctica in 1947 with the largest expedition ever to explore the continent and surrounding waters. It involved more than 4,700 Navy and Marine Corps personnel, 13 ships and a number of aircraft, producing the first medium-scale maps of the region. Nearly 12 years later, from mid-1957 to the end of 1958, worldwide interest in the Earth's environment led to the International Geophysical Year. As part of this initiative, 12 nations established 65 research stations on Antarctica. The United States occupied seven of these stations, including one at the South Pole. The U. S. Navy provided logistic support for the

U. S. stations. The United States continued its year-round presence in Antarctica and established a permanent science program as the U. S. Antarctic Program.

In 1959, the United States signed the Antarctic Treaty which preserved freedom of access to the continent and its surrounding waters for all nations, prohibited all military activities on the continent, and reserved Antarctica for science and other peaceful purposes. The Navy remained in Antarctica to provide logistic support to the U. S. Antarctic Program.

In 1976, National Security Decision Memorandum Number 318 directed that the U. S. Antarctic Program be fully managed by the National Science Foundation, who would budget for all science and logistic functions and reimburse any other agencies supporting the program. White House Memorandum 6646 of February 5, 1982 continued this arrangement, directing the Departments of Defense and Transportation to provide logistic support requested by the National Science Foundation on a cost-reimbursable basis. It also directed the National Science Foundation to use commercial support and management facilities where these were determined to be cost-effective.

Today, the National Science Foundation has three permanent stations in Antarctica to support its research program. During the austral summer, nearly 2500 scientists, support personnel and visitors require transportation to the permanent stations as well as to isolated field camps around the region.

Throughout this period of time, the Navy has provided logistic support for the U. S. Antarctic Program, dedicating as many as 850 billets for providing a full range of ground and air support functions. We have provided public works, waste disposal, hazardous waste management, food services, janitorial functions, air traffic control, weather forecasting and air logistic services, to name a few. During an average season (October to March), the Navy's Antarctic Development Squadron (VXE-6) flies 3800 hours in direct support of this program. The aircraft are specially modified ski-equipped C-130 military cargo planes (LC-130), owned by the National Science Foundation and operated by the Navy. They are uniquely designed for polar operations and are capable of reaching any location on the continent.

Department of Defense Support Functions

Although the Navy has provided the bulk of the support functions to the U. S. Antarctic Program, other Department of Defense organizations have also contributed their support:

- The Military Sealift Command has provided bulk cargo and petroleum sealift;
- The Department of the Army has augmented trans-shipping terminal operations;
- The Defense Logistics Agency has managed the supply of food, fuel, and other consumable products for delivery to the Antarctic;

- The Air Force and the Air National Guard have provided inter-continental heavy airlift and augmented inter-continental airlift across the Antarctic continent.

The Department of Transportation, through the U. S. Coast Guard, also supports this program by supplying ice-breakers to clear the way for fuel and cargo vessels to McMurdo Station. Coast Guard vessels also serve as platforms for conducting scientific research in Antarctic waters.

Transfer of Navy Logistical Support Functions

The Navy has had a long and proud history of supporting the science program in Antarctica. It is a unique and fascinating mission, and it was with some serious reluctance that the Navy began in earnest in 1992 to consider withdrawing from this operation.

The Post-Cold War drawdown of funding for ships, aircraft, and other weapon systems put severe pressure on the Navy, along with the other military services, to focus their assets on core military requirements, and to reduce or eliminate non-essential missions. Despite reimbursement, billets used to support the U. S. Antarctic Program count against the Navy's military end-strength ceiling, and are not available for manning Navy ships and aircraft. The Antarctic support mission required unique training needs, one-of-a-kind aircraft maintenance and support needs, complicated personnel rotational assignments, yet provided limited operational benefit.

In March 1993, the Navy hosted a two-day workshop with representatives from the National Science Foundation, the Air National Guard, the Coast Guard and the National Oceanic and Atmospheric Administration to begin exploring other logistic support alternatives. The group proposed a three-phase Navy withdrawal plan to (1) commercialize base support functions, (2) commercialize Antarctic helicopter operations, and (3) withdraw the Navy from the LC-130 operations.

The Navy and the National Science Foundation have been successfully implementing the first two recommendations. Most of the base support functions have now been contracted out by the National Science Foundation, reducing Navy manning by almost 300 billets. Last week, the National Science Foundation awarded a contract for commercial helicopter operations which will reduce Navy end-strength by about 100 more billets. A detailed list of functions being contracted out, and their transition status, is outlined in the National Science and Technology Council's April 1996 Report on the U. S. Antarctic Program.

The lack of commercial capability to provide the kind of ski-equipped, fixed-wing air support required by the U. S. Antarctic Program provided no commercialization opportunities for this function. The Navy and National Science Foundation discussed this requirement with other government agencies. The Coast Guard considered taking on the mission as an extension of their current C-130 operations. The National Oceanic and Atmospheric Administration, which has a fleet of aircraft that support science, also considered the mission. The National Science Foundation encouraged a close look at the Air National Guard for potential "single-point management" of fixed wing logistic support for Antarctica. The Air National Guard had already been augmenting Navy operations in Antarctica since 1988 with use of their own aircraft, and they also have had a complementary role of LC-130 logistic support in the Arctic since 1975.

In December 1994, the Director of Defense Research and Engineering proposed the transfer of this function from the Navy to the Air National Guard. The Navy, Air Force and the National Science Foundation agreed that transferring the Antarctic LC-130 operations from the Navy to the Air National Guard had many advantages:

- The Air National Guard has a core wartime mission for flight support in polar regions, while the Navy has no such mission.

- The Air National Guard already maintains a robust C-130 infrastructure, and is mission-funded to train, maintain and fly ski-equipped LC-130s for Arctic missions. The Navy has no other active duty C-130 operations. The VXE-6 Squadron is a single-purpose requirement for training, maintenance and operation of the LC-130 aircraft for this non-warfare operation.

- The Air National Guard has experience in the Antarctic environment. They have augmented the Navy's support to the U. S. Antarctic Program with nearly 500 flight hours annually.

- The U. S. Antarctic Program complements the Air National Guard mission. Since operational requirements for each pole occur in opposite seasons, both missions can be supported by the same aircraft, personnel, and infrastructure with only a small enhancement to the current Air National Guard levels.

- The transition provides substantial savings to the National Science Foundation in terms of direct costs and reimbursable expenses to the Department of Defense. The merging of Arctic and Antarctic activities into year-round polar operations will reduce by half the number of full time military billets reimbursed by the National Science Foundation for Antarctic support. Part-time (reserve) Air National Guard personnel supporting the U. S. Antarctic Program will be reimbursed only while in a full duty status, thus reducing overall personnel costs substantially.

- The transition also provides the opportunity to defer procurement of new aircraft, which the National Science Foundation planned to seek within the next six years. Both the House and Senate Defense Appropriations Bills fund upgrades to the Air National Guard's older LC-130 aircraft to improve operational safety, extend the life cycle of the aircraft, and reduce maintenance costs. The Air National Guard has asked the National Science Foundation to also budget for upgrading existing National Science Foundation aircraft to ensure full compatibility of all aircraft supporting Antarctic operations. Combining the upgraded National Science Foundation

> aircraft with newer Air National Guard aircraft into a larger fleet of LC-130s will spread flight hours over more airframes, extend the service life of the entire fleet, and defer purchase of new aircraft until 2030. The deferred aircraft procurement savings to the National Science Foundation are estimated to be $350 million over 35 years.

Based on all of these considerations, the Air Force agreed in February 1995, with the National Science Foundation approval, to assume the Navy's remaining air logistic role. The Navy, Air National Guard, and National Science Foundation representatives have been working in close cooperation to develop a detailed three-year phased transition plan to acquire and train personnel, draw down the Navy's role and stand up the expanded Air National Guard mission while avoiding any impact on the U. S. Antarctic program operations. This plan was endorsed at a February 1996 meeting called by the Director of Defense Research and Engineering.

The transition started in March of this year, with the Air National Guard hiring personnel to provide an additional 300 flight hours for this coming season, which runs from October 1996 to March 1997. In the second year, the Air National Guard will increase its support to more than 40 percent of the total flight hours. In March of 1998, the Air National Guard will officially assume operational command of the Department of Defense fixed-wing air support to the U. S. Antarctic Program. By the third year, the Navy will have reduced its role to 195 billets and about 30 percent of the flight hours. The transition will be completed in March 1999, when the Navy's role in the U. S. Antarctic Program will come to a close.

Of particular concern in the transition is maintaining safety of flight operations on the ice. We are fully addressing this concern. Last year, I visited Antarctica to get a full understanding of the complexities of the mission. I am well aware of the safety issues involved. I have asked Rear Admiral Paul Tobin, Oceanographer of the Navy, to visit Antarctic this season to observe firsthand the Navy, Air National Guard and commercial operations to ensure that the transition is proceeding smoothly.

Conclusion

Mr. Chairman, the Department of Defense is convinced that replacing the Navy support to the U. S. Antarctic Program with a mix of private contractors and the Air National Guard is a very sound approach. The three-step transition mutually agreed to by all parties is well underway: The first step - commercialization of base support functions - is nearly complete. The second step achieved a significant milestone when the National Science Foundation awarded a contract for Antarctic helicopter operations last week. We initiated the final step to transition LC-130 flight operations to the Air National Guard in March of this year. This last step will be phased in over the next three years, with the Navy concluding its logistic support role for the U. S. Antarctic Program in March 1999.

Single-point management of LC-130 operations by the Air National Guard will reduce the costs to the National Science

Foundation and the nation by eliminating duplicative Navy/Air Force infrastructure and providing one organization with a year-round mission. The Air National Guard mission is enhanced consistent with a part of their wartime mission. I am confident that they can do the Antarctic air logistics job and do it well

The Department of Defense will remain a critical provider of support to the U. S. Antarctic Program through the Air National Guard, the Defense Logistics Agency, the Military Sealift Command, and the Air Mobility Command. We are committed to ensuring a seamless transition from the Navy to the Air National Guard with no impact on the science and the safety of the U. S. Antarctic Program.

That concludes my statement. I would welcome any questions.

Chairman SCHIFF. I would like to again reiterate I appreciate the testimony of all of the witnesses and that your full written statements, if not entirely presented, will be made part of the official record of this hearing.

I would like to recognize myself now for five minutes, and if Members desire another round of more than five minutes I would be inclined to recognize them. I think this is truly an issue where all sides of the aisle and all agencies of government are in common interests, and I think we all have the same goals. I don't think there is any philosophical difference here between any of us.

I would actually like to begin with Dr Sullivan. I have a couple of scientific questions to ask.

The first is it's my recollection from high school geography that the Antarctic is a continent, but the Arctic may not be. Do I have that right, or are they both continents?

Dr. SULLIVAN. You're quite right and you probably got an A in that class, Mr. Chairman.

Chairman SCHIFF. I did better in political science, I can tell you that.

[Laughter.]

Do I have that right and, if so, can you explain why one would be classified as a continent and one would not?

Dr. SULLIVAN. Well the Antarctic continent, what you see on the chart behind me, is a land mass surrounded by an ocean, and the land mass is covered with ice—glacial ice—and the ocean is covered with ice that's sea ice—frozen ocean so cold, two degrees below zero—the ocean freezes.

In the Arctic you have almost exactly the opposite. The geophysical differences between these regions that we tend to think of as the same is really dramatic, because in the Arctic, which I unfortunately don't have a chart of, you have an ocean right in the center. The North Pole—you couldn't stand on the North Pole unless you were able to stand on a floating piece of frozen sea ice that's about ten feet thick.

Chairman SCHIFF. So there is no land mass there is what you're saying.

Dr. SULLIVAN. That's right. It's an ocean basin and it's surrounded by the land mass of North America, Europe and the Soviet Union. So you have just the opposite. You have an ocean surrounded by land in the Arctic; and in the Antarctic, land surrounded by ocean.

Chairman SCHIFF. But some portion of the Antarctic, as you say, is frozen water, too, because you've referred to some instability in certain areas.

Dr. SULLIVAN. That's correct. On top of that frozen continent is a layer of ice approximately two miles thick, and 70 percent of the earth's fresh water is there. It's just not liquid. It's frozen solid in the glacial ice covering the Antarctic continent, the polar ice cap as it's often referred to.

Chairman SCHIFF. My second scientific question is you made reference to locating life forms in the ice, and maybe I wasn't hearing correctly what you meant, but I got the impression you were talking about almost-life forms in kind of a suspended animation that might have been there for quite some period of time but were still alive.

Dr. SULLIVAN. You're correct with both of the statements. In the glacial ice, the very thick layer of ice that may be on the order of 400,000 years old at the deepest part down 3,000 meters from the surface; and along that ice profile have been identified microorganisms—single-cell bacteria that are believed to be as old as the ice. They probably came from the atmosphere. They're frozen and there is no water there. They are in, as you said, in suspended animation—almost like freeze dried coffee. They're probably lyophilized.

In the sea ice that covers the ocean it's quite different because when it freezes it freezes as solid ice, but the salt of the sea water drains out of it, and then it drains out in tiny pores about the size of a human hair and there is liquid water in there, and in that ice you have bacteria and single-cell algae that can grow because they have a liquid water environment. As a matter of fact, they are present there in one-to-two-thousand times higher concentration than they are in the water beneath the ice.

So it's really quite a fascinating area and those organisms actively grow, and they increase a thousand-fold during the year. The interesting part of it, besides being an important and unique part of an ecosystem, is that these organisms, because they grow at low temperatures, have enzymes, catalysts for chemical reactions that work very well at low temperature and there are a number of patents now that facilitate industrial processes where you don't need to add energy to warm up the liquid medium because the enzyme works at zero degrees or very cold temperatures.

Chairman SCHIFF. I think you've just given one example of why Antarctic research and polar research is so important.

Mr. Scully, I would like to ask you, if I may, about international cooperation. You made the general statement about other countries participate and pay their fair share; but I would like you, if you can, to give me a little bit more detail about that. In other words, how many countries are significant participants in Antarctic research, and what percentage of the total cost do you think that they bear?

Mr. SCULLY. Thank you, Mr. Chairman. I may have to also rely on Neal a bit on this, since I gather NSF has done some studies.

First of all, as mentioned in the testimony, the Antarctic Treaty itself is fairly unique in that it links decision-making to activities. So that the original twelve parties of the Antarctic Treaty were the twelve countries that were active in Antarctic research. There are now 26 countries that have met that criterion, the twelve plus an additional fourteen obviously. The United States remains, as it was then, the leading nation in terms of the extent and commitment to investment in Antarctic research.

Of the 26, I would say that probably at least half of those have very significant programs. There are others whose programs have varied over time, some of the other nations that are active in Antarctica. Belgium, for instance, which was one of the early countries in Antarctic research, is less active in field work now and more active in sort of the laboratory work in terms of analyzing Antarctic data.

But I would say, and again correct me if I'm wrong, Neal, this came up in the NSTC study, our estimate I guess would be that the United States is probably responsible for about a third or 25 percent of the investment in research in Antarctica. There are, as I said, other major players, including the Russians, including the Argentineans and Chileans, the U.K., Australia and New Zealand.

But perhaps you would like to supplement that briefly, Neal, in terms of the information.

Chairman SCHIFF. Well I'm going to have to interrupt because my time has expired, but you've answered my general question. If you believe that our investment is no more than 25 percent to a third, it means there has to be significant contributions coming in from other countries, and that's the point I was getting at.

Mr. SCULLY. There are, and I think again one of the interesting phenomena in Antarctica is that basically there is kind of a barter system that operates. There is a lot of cooperation in research, some of which is simply exchange of personnel and exchange of logistic opportunities because logistic opportunities really are what constrain the ability to conduct research.

Chairman SCHIFF. I understand. My time has expired.

Mr. Cramer, you're recognized for five minutes.

Mr. CRAMER. Thank you, Mr. Chairman. I will be brief.

Dr. Sullivan, are you familiar with the current design study for the South Pole Station replacement?

Dr. SULLIVAN. Yes, I am.

Mr. CRAMER. Are there other options for that that are less costly?

Dr. SULLIVAN. Yes. The current design that has been approved within the Science Foundation and by the Science Board is the so-called "110-person enhanced station" that would enable about 58 scientists to work in the summer and about 52 people who support science to be there during the summer also, and then during the winter that station would have about 28 people.

As the design was developed over about a six-year period and at a cost of about $13 million, which included prototype testing of buildings, that station was costed at about $181 million. However, as the Chairman noted, with the $25 million MRE account sum to address the most urgent health and safety issues our estimate is that that cost would be now in '96 dollars about $143 million and not 181.

The smaller station, the hundred-person station, would cost about $11 million less, and the difference between the two is the idea of enhanced; that is, if we spend eleven additional million dollars in building the station we would build in the kind of infrastructure which by the time the station is built, if it is built in eight years, that if we were in a different budget climate or for policy reasons or science reasons or other reasons we wanted to have a more substantial facility there, we would be able to build that at relatively less cost.

Mr. CRAMER. Could we consider an option that it would be an internationally operated and funded South Pole Station, and I ask that for any of the panel members?

Dr. SULLIVAN. I would be glad to give you my input for it. I think we could increase the amount of international cooperation at South Pole and at other stations. We have a lot now, but as I see it, it could be going along a continuum. Right now we have scientist-to-scientist cooperation and we have countries agreeing to address very large and very costly scientific projects.

It's not inconceivable to me that we could take that another step further. Perhaps a logical step would be to ask other countries to contribute to some of the scientific infrastructure, say an observatory or a laboratory at any of the stations or at the South Pole Station.

Where I and the Science Foundation, as we've discussed it, would begin to become concerned is if we asked people to buy in, other nations to buy in to the core facilities of the South Pole Station, and that is go beyond the science buildings to the habitat where people live and where you need to be to survive the winter because of the difficulties primarily in managing a complex program like that.

It's already complex, believe me, and that complexity I think may be of concern both for policy reasons and maybe more immediate ones as just coordination and health and safety reasons because the management of that station is tied in intimately to the logistic change, and right now that logistic change obviously involves the Department of Defense, and that's where I would start to see problems.

Mr. CRAMER. Dr. Moniz, yes, please, especially in light of your testimony.

Mr. MONIZ. The NSTC report explicitly charges the NSF to inquire and to explore international collaboration. So that is part of the charge to the Foundation. However, the NSTC working group tempered that by the statement, as I said earlier, that we do believe, as Dr. Sullivan in effect described, that we should consider retaining basic authority and control largely for reasons of safety, working in a very harsh environment and reflecting the fact that, for example, we are the only operators of the kind of aircraft required to service it. So we should welcome involvement in some laboratories and some housing perhaps, but not in the core facilities.

Mr. CRAMER. Thank you. That's all for now.

Chairman SCHIFF. Thank you.

Mr. Gutknecht. Mr. Gutknecht, I'm sorry to interrupt for a moment, but as I explained to our panel before, there are some comings and goings, and I'm due on the House floor to present an amendment. So, Mr. Gutknecht, I'm going to ask you to Chair, if you will, and at the same time recognize you for five minutes, and I know you have to go in a little bit and we'll have another Member take your place.

I want to again tell the panel members that your testimony is all being made part of the record even though we have to do some comings and goings here.

Mr. GUTKNECHT. Thank you, Mr. Schiff.

I first of all what to ask Dr. Sullivan a question. I'm not sure I heard correctly. You said that 70 percent of the world's fresh water is where?

Dr. SULLIVAN. Seventy percent of the world's fresh water is frozen in the glacial ice cap that covers the Antarctic Continent.

Mr. GUTKNECHT. Just the Antarctic or including the Arctic?

Dr. SULLIVAN. Just the Antarctic.

Mr. GUTKNECHT. That's a great statistic.

Mr. Scully, I don't have a whole lot of questions, but you have said repeatedly in your testimony this afternoon that the United States has a national interest and you indicated that reducing the scale of the U.S. Antarctic Program would have an impact apparently on foreign policy. Is that a fair characterization?

Mr. SCULLY. Yes, it is. The Antarctic Treaty as noted is linked, influences, et cetera, to involvement in activities. So that the level of our activities in fact is the basis I think of our leadership and our influence within that system. The system itself, as I think has been noted, serves a whole variety of U.S. interests, the primary expression of which is science. But the fact that the area is an area that is demilitarized and which is free of conflict has been a major benefit I think to our overall foreign policy because it's our view that without the Treaty there would be significant conflicts which we would find it hard to be absent from I think with regard to the continent.

Mr. GUTKNECHT. The question I have is, and we had to wrestle this year to try and get increases in the authorized funding levels, have the folks at State ever considered helping to participate in the overall costs of the operations down at the Antarctic?

Mr. SCULLY. I think some folks probably have and some others probably would be very unhappy with that. First of all, we do in fact contribute, and at least in terms of the Treaty operations, we do find the U.S. participation in the Antarctic Treaty, which is obviously not anywhere at the same level of magnitude as the science program itself, but there is an expenditure in terms of our undertaking activities within the Treaty, including the participation in Treaty meetings, hosting meets, et cetera.

Second, though I think the history of U.S. Antarctic policy in terms of the budgeting for the program has been the recognition that there are not only cost efficiencies, but there are also important policy reasons for single-agency management and funding of the program itself. I think the way we look at it is that rather than looking upon this program as the purview of any particular Federal agency, we see and fully endorse the reason for single-agency management and funding, but we believe it should be recognized that the NSF is managing a program that is not simply "an NSF program," but it's a program that serves a whole variety of our national interests.

Mr. GUTKNECHT. The other follow-up question I had was relative to the profile for the logistic support. We're in the process of transferring it from the Navy, and could you fill in the blanks of how is this process going to work and where will the money come from?

Mr. PIRIE. The logistic support provided by the LC-130 aircraft which are ski-equipped is being transferred from a Navy squadron, VXE-6, that operates them now, to the 109th Air Transport Squadron of the Air National Guard, and it's simply a matter of who flies these airplanes. The airplanes that the Navy flies now are owned by the National Science Foundation. The Air National Guard has some LC-130 ski-equipped already because they have an Arctic mission, and it seems logical simply to transfer the duty of flying the National Science Foundation's aircraft to the Air Guard as well.

Mr. GUTKNECHT. My colleague from South Carolina was asking how do you get there. I mean if you start in New York you fly these C-130s to where?

Mr. PIRIE. The C-130s are generally staged down into the Antarctic through Christ Church in New Zealand. It's about an eight-hour flight from Christ Church down to McMurdo Sound.

Mr. GUTKNECHT. Would they leave New York and fly all the way to Christ Church?

Mr. PIRIE. No. They've got to make various stops on the way, and my Air Force colleagues can fill me in.

Honolulu, Pago Pago and then Christ Church. So they skip across the Pacific Ocean.

Mr. GUTKNECHT. I have no further questions.

I would yield for five minutes to the gentleman from Missouri.

Mr. VOLKMER. Thank you very much.

Dr. Sullivan, may I suggest that you invite some of the Members of this panel who have been talking about this to you down to the Antarctic. It might be very helpful for them to understand the situation down there.

Dr. SULLIVAN. I would be very pleased to do that.

Mr. VOLKMER. I think you could do that and you would have the opportunity to do that sometime.

Dr. SULLIVAN. We would have the opportunity. We've done it before, it's most enjoyable and we would look forward to it.

Mr. GUTKNECHT. If the gentleman would yield, I doubt if anyone in the press would call that a junket.

Mr. VOLKMER. Well they may, but I don't think you'll find it to be that.

But really the other thing I think would be maybe interesting for us in listening to some of the questions here is, Mr. Scully, as brief as you can without taking a lot of time, can you give us a little bit of the history before we had the Antarctic Treaty of what was going on down at the Antarctic between the various countries that were already there on the question of exploration and mining and everything else.

Mr. SCULLY. Well there were several stages in the sort of pre-Antarctic Treaty history of Antarctica, and I'll try to be real brief. First you had the sort of initial contacts in the 19th Century, and what brought people to Antarctica, and obviously it included exploration, trying to find and discover the unknown, but also resources brought the first sort of economic activity in terms of sealing and then commercial whaling. So that the first economic activities there were sealing and whaling which began in the 19th Century largely from land stations, and there was a reasonably unhappy history of that activity in the sense that the populations first of seals and then of whales were over-exploited and decimated. So you had then economic activity, and the exploration and the economic activity with respect to whaling and sealing generated the interest of countries in making claims which began.

So in the beginning of the 20th Century you had both the exploration, if you will, of the marine areas of the continent largely completed, and then the beginning of an expression of interest in territorial claims, plus in the early 20th Century you had the heroic explorations of the interior of the Continent, Scott, Amundsen, et cetera. So by the time of the early part of the century a number of countries had made claims to Antarctica.

During the period before World War II, then I think the major event really was the aircraft and Admiral Byrd's pioneering expeditions which really opened up the interior in terms of beginning to look at what the nature of this continent was and beginning to find out more about it.

There was a pause in activities because of World War II, but I should note that by the time World War II occurred, the seven countries that claimed pieces of Antarctica had all made their claims by that time. Some of them were generated by a fear that Germany, that the regime in Germany, that Nazi Germany might make a claim to Antarctica in the period just before World War II.

After World War II, I think there was a major interest in exploration and a much more organized interest in exploration building on the expeditions that Byrd and others had conducted before World War II, and I think those explorations led to the major interest in the international scientific community as the sort of major unstudied area of the planet, both to learn about the nature of this continent itself and also to learn about its relationship to other parts of the globe. So I think this age of exploration turned into an age of science.

I would note again though that during the early '50s there were instances in which there was actual conflict among the countries that had competing claims. There were actual incidents between the U.K. and Argentina, for example, in the Antarctic Peninsula that raised fears of actual physical conflict between those countries. So there were the political aspects of Antarctica and the potential problems associated with the claims issue began to come to the fore.

The other point that I would mention is during the early age of exploration, in addition to the continental areas, and Neal has mentioned the marine areas, I think one of the interests that began to develop with the exploration of the oceans, the southern oceans around Antarctica was the potential for living resources in addition to whales and seals that had been exploited, but for fisheries and other marine resources. So that another stream of development that was generated I guess by the science activities were the efforts to conserve resources, and there have been other elements of the Antarctic Treaty, the Antarctic Treaty system, that have established means of conserving the living resources and regulating fishing activities around Antarctica.

So that would be I guess a real thumbnail sketch, and my colleagues may wish to supplement that.

Mr. VOLKMER. Now under the Treaty that we have all the countries recognize everybody else's rights there, is that correct, and it also limits what can be done there? That's very important.

Mr. SCULLY. Those limitations are very important. First of all, I mean the major provisions are that the activities in Antarctica are strictly limited for those that serve peaceful purposes. Military activities, the testing of weapons and nuclear activities are prohibited.

As a result of agreements subsequent to the Antarctic Treaty itself there are strict regulations that apply to the taking of fish, fishing activities, living resource activities. There is a very strict regulation on the taking of flora and fauna for scientific purposes. So that basically there is a prohibition on the taking of native flora and fauna except for scientific purposes, and even then under very controlled circumstances. Then most recently there has been a prohibition on mineral resource activities in Antarctica that was negotiated in the early 1990s.

So you have a treaty system that started with an emphasis on the freedom of science and a prohibition on military activities, and it has evolved into a system of governance that has dealt with other human activities as those activities have become possible, prohibiting some and regulating others strictly, basically to make sure that the continent is reserved primarily for science and its value as a laboratory for science is not compromised.

Mr. VOLKMER. Dr. Sullivan, in the event that the South Pole Station, the Scott Station, is replaced, you will, I hope, remove all the old buildings, et cetera, that are not used that are there and not just leave them.

Dr. SULLIVAN. Yes, we would. Part of that cost estimate that I gave you earlier includes the dismantling and removal of the existing station that we know of. There are parts of previous stations that are not very substantial, they're not like the geodesic dome, that were buried long ago and they're restricted areas. So I've never actually seen what they are or what they look like. They're beneath the polar ice cap right now.

Mr. VOLKMER. Thank you very much. I have no further questions.

Mr. GUTKNECHT. The gentleman from South Carolina, Mr. Graham.

Mr. GRAHAM. Thank you, sir.

About the aircraft, are we talking about substituting a different squadron of planes or just pilots?

Mr. PIRIE. It's just pilots. There are seven of these LC-130s that belong to the National Science Foundation and seven to the Air Guard, and the ones that belong to the National Science Foundation have been piloted by Navy pilots up until now and will gradually phase in Air Guard pilots to take over those aircraft.

Mr. GRAHAM. Being an Air Guardsman, that's a good idea. There's nothing wrong with the Navy flying though.

Mr. PIRIE. I think the Air Guard will do a fine job and this is an excellent tool for its mission.

Mr. GRAHAM. Well great. A real simple question because that's about all I can bring to the table. If I'm talking to someone back home in my district about what's going on in Antarctica, what would you say is the biggest single benefit that we've gained from having a station at the South Pole as far as what we know about our planet or what we have learned about resources?

Dr. SULLIVAN. I think many people would say the largest environmental question and surprise came out of the late 1950s observation by the British of a depletion in the ozone; and the South Pole Station and the Program along with other agencies, such as NASA and NOAA, have built a story about the ozone hole with data from satellites and from ground measurements, and it shows that probably the greatest pollution, I would say, of the Antarctic has occurred not in the Antarctic, but by what our activities have put into the atmosphere and have migrated to the Antarctic region to create this depletion of ozone which is related to directly the increased flux or the radiation in the ultraviolet light region, UVA and UVB, which has a deleterious effect on living things because that ultraviolet light, which in a doctor's office may be used to sterilize a surface of skin or some material that's going to be implanted in a human body, has the real and potential effect of causing mutations or in an extreme causing death to organisms.

Now as long as that ozone depletion is restricted to the Antarctic Continent perhaps ten percent of the people in the United States or in the world will look at it with academic interest, but should it expand beyond the Antarctic in particular to become a larger or deeper hole, and if that ultraviolet radiation were to influence the human habitated regions of the earth, particularly say areas around South Africa, New Zealand and Australia where agriculture is an important way of life and crops are important and the health of people who could be impacted by that increased ultraviolet light because it is known to potentially cause increased skin cancer or cataracts, then I think a demonstration for we'll say all of humanity would be one of the outcomes.

Very simply stated, there has been an observation of reduced ozone in the Arctic region as well. The chemistry and the atmospheric science surrounding that observation is not as clear as it is in the Antarctic, but it is of concern mostly because that area, as you know, is an inhabited area of the earth. The Northern Hemisphere has a lot more land mass. It's where we live and the Europeans and the Soviets live and the Asians. So it is of concern and an area of intense interest.

Mr. GRAHAM. One final question. What is the biggest potential that we can gain from further exploration and research in this area, in your opinion, on the horizon? What do you see as the biggest benefit for continuing to do what we're doing?

Dr. SULLIVAN. To me the biggest benefit of science generally is that we're going to discover what is unknown to us. So I can't give you an increased number of patents on processes that we've never thought about or new neutrino astronomy so we know more about the universe and so forth. It's really that we're at the cutting edge of the intellectual adventure of man and mankind, and women, too. Obviously, 30 percent of the people in Antarctica are women, and that has a lot to do with some of the sayings that are written here around the room. Where there is no vision the people perish. It gives us hope for discovery.

Mr. GUTKNECHT. The gentleman's time has expired. That wasn't what that bell was all about.

[Laughter.]

We have to vote, and we have 15 minutes.

Mr. VOLKMER. Mr. Chairman, I just have a short question, and that is the ozone layer, the depletion that has occurred, is that continuing to deteriorate or is there a slow-down? I thought I read somewhere where it had pretty well slowed down, or do you know for sure? Does anybody know? Can you tell me?

Dr. SULLIVAN. We continue to see the effect of ozone depletion.

Mr. VOLKMER. All right.

Dr. SULLIVAN. The rate at which the ozone is depleted has slowed, but there is still a substantial rate that occurs, and the projections from models that I've seen suggest that it will be well into the next century, on the order of decades into the next century before that ozone recovers or is likely to recover. It is a model and it's based on some assumptions, and it's also based on the fact that people of the earth continue to honor the international agreements not to produce or release fluorocarbons into the atmosphere.

Mr. VOLKMER. Again, just for edification, you used to have pictures of that ozone hole down there, and I don't know if other Members have seen them, but it was quite edifying for me several years ago when I did. Thank you.

Mr. GUTKNECHT. But it is true that the ozone hole is shrinking, or at least the belief now is that the hole is shrinking?

Dr. SULLIVAN. That's not my understanding that it is shirking. There is a natural variability, a few percent in each direction. It's really called an ozone anomaly. It is an atmospheric phenomenon that moves around the continent. It changes in shape and in size during the season. It's best monitored by NASA and NOAA satellites which can see synaptically the entirety of the polar region, and those satellites' data is a sensor data that is confirmed by people on the ground making direct measurements and people making direct measurements using balloon sensors so that you can tell that it is real and measure it very explicitly in a vertical assent of a balloon. But my understanding now is that while it does not appear to be growing at the rate that it was during the past decade, it is still increasing.

Mr. GUTKNECHT. Just one final question that I had, and that is you've talked about rebuilding or building a new station down in the South Pole, but you've sort of danced around how exactly we're going to pay for it. One of the concerns that we have is that it's going come at the expense of other research. The $25 million that we talked about earlier, that's going to go to improvements to the current facility, and then we're talking about building a new facility at a cost of somewhere between $143- and $180 million. Am I correct in all that?

Dr. SULLIVAN. That's correct. The $25 million would be used to correct the most urgent health and safety issues at the current station. Those issues are a new power plant and fuel-containment containers so that we have double-walled tanks to avoid fuel spills, and those additions of both the fuel tanks and the power plant would become a part of a new station, if a new station were to be built. So they're definitely separate.

Mr. GUTKNECHT. So the $25 million will not be wasted.

Dr. SULLIVAN. Absolutely not. It's not being used on something that would be torn up and retrograded when you build a new station. That's absolutely true.

Mr. MONIZ. May I just add to that. Mr. Gutknecht, of course we share your concern about having the South Pole renewal go forward, but yet we're also concerned about the research. Two comments coming from the report.

First, that is one reason why we had such strong emphasis on the need to keep trying to wring additional savings out of the operations and asked that this panel be formed which will have individuals with varied experiences operating in harsh environments, et cetera.

Secondly, in the charge to that panel, one of the scenarios specifically spelled out in the report is to look at a several-year freeze in funding with South Pole Station construction in that envelope. So that is one of the specific directives to the panel.

Mr. GUTKNECHT. Well I want to thank the panel. I'm going to have to run and vote. We will be back. I will dismiss this panel. I'm not sure who will be the Chair when we come back from the vote, but I do want to thank you for being with us today and sharing this very important information. We all have a big stake in what's going on down there, and we never know what we're going to learn until we get down there and find out.

So thank you very much for being with us, and I'm going to recess the Committee for approximately fifteen minutes for the vote.

[Recess taken for Members to vote.]

Mr. CRAMER. Well there has been a friendly Committee takeover here.

[Laughter.]

Remember I used the word friendly now. I think it's appropriate that we move on with panel two, and we will in fact do that.

We will now hear from Dr. Robert Rutford, who is Professor of Geosciences at the University of Texas at Dallas, and Dr. David Clark, who chairs the Department of Geology and Geophysics at the University of Wisconsin at Madison. Welcome both.

Dr. Rutford, we'll start with you.

STATEMENT OF DR. ROBERT H. RUTFORD, EXCELLENCE IN EDUCATION FOUNDATION CHAIR, PROFESSOR OF GEOSCIENCES, THE UNIVERSITY OF TEXAS AT DALLAS

Dr. RUTFORD. Mr. Chairman, I'm better known as Bob Rutford. I'm a Professor of Geosciences at the University of Texas at Dallas where I hold a Chair in the Sciences. I began my——

Mr. GUTKNECHT. Is your microphone on?

Dr. RUTFORD. No, it's not. I began my work in the Antarctic 1959, and I did my Ph.D. dissertation in the Ellsworth Mountains. I've served as Chairman of the Polar Research Board, and I currently serve as the U.S. Delegate to the International Scientific Committee on Antarctic Research which is under the auspices of the National Academy of Sciences.

It's an honor for me to be here today and to represent the Scientific Committee in the discussion of the recent report from the NSCT.

One of the advantages of being on the second panel is that you don't have to repeat a whole bunch of stuff that has already been said before. So I will skip over some of the things that I was going to say because it would simply be a repeat of previous testimony.

I think it's well recognized internationally that the United States Program in Antarctica is providing the leadership role in Antarctic science. I think I'm safe in saying that the current research activities are providing questions that are not only relevant to the Antarctic, but also to the greater scientific community, and finally I think I would be safe in saying as a former Director of the Division of Polar Programs that the present research in the Antarctic is of the highest quality and may well be the best overall science that the Office of Polar Programs has ever supported.

The NSTC report that I'm sure you all have contains several pages in the text that are slightly different color than the regular text and I would urge you all to read those because they give you a very brief and a very useful overview of some of the science activities at the various stations and in the field.

It has already been mentioned, but I would mention again that the special support provided by Congress over the last four or five years has allowed the U.S. to become a leader in environmental as well as scientific issues. Having been involved now since 1959, I can tell you that a visit to McMurdo Station and Palmer Station in the 1990s is a real pleasure, and the cleanup that has occurred there is one that the United States can take a great deal of pride in, and it's amazing how much as taken place there.

Secondly, with regard to this Committee, some of you know that I testified here a couple of months ago urging you to get on with House Resolution 3060, and I'm pleased that the House has passed that. In my written testimony I urge you to urge your Senate colleagues to get on the ball. Early next month I'll be going to the biannual meeting of the International Scientific Committee on Antarctic Research and I would love to be able to tell them that the bills had been passed by both houses, that any differences had been resolved and we were waiting for the President's signature.

Mr. Scully has referred in his testimony to one of the aspects of the U.S. Program in Antarctica that is very often neglected, not only by the scientists, but by other people. On page 12 of the NSTC report there is reference that the South Pole Station is both a symbol of the U.S. commitment to assert its rights in Antarctica, namely, a territorial claim, but it's also a symbol of the commitment of the U.S. to conduct leading-edge research under the most hostile conditions found any place in the world.

Some have argued in the past that the South Pole Station is the symbol of U.S. presence and that's the only reason for it, and I heartily disagree with that view. The present and future use of the very special conditions found at the South Pole by those doing various kinds of studies will continue to produce outstanding observational opportunities and data that can't be found any place else on the earth and year-round operation of the station to provide continuous observation of data is essential.

My reading of the report suggests to me that the Committee waffled a bit about the future plans for the South Pole Station. The National Science Foundation for six years has carried out various studies relating to the future of the station and the need to replace it. I chaired a committee for the National Research Council a couple of years ago talking about the awarding of grants and the big awards in the NSF and the need for NSF to kind of open up the process. They've done that with regard to the South Pole, and I think anybody who has anything to say about the future of the South Pole Station and the need to continue it has had an opportunity to make input into that process.

If you were to ask people 25 years ago if astrophysical research would ever be done at the South Pole I think the resounding answer would have been no because nobody had thought about it, and yet that has become the basis of the station now and the scientific research in astrophysics has become the rationale for the station.

Now to build a station to support astrophysical research today would be, in my view, wrongminded also. What we ought to be building there is a station that can support any kind of research over the next 25 or 30 years because a mix of science at the South Pole may be totally different 25 years from today than it is right now.

And finally somebody asked a question, you know, what kind of research will be done there, and my response to that is if I could tell you that, we wouldn't do it because we wouldn't have to do it. So this is the intriguing part about science, that you go into things with the hope that you're going to discover something, and if you knew what it was, it wouldn't be any fun.

With regard to the logistic support, the present mix of station ships and aircraft provides the U.S. science community with the opportunity to do high-quality and extremely flexible, broad-based research activities any place on the continent. The LC-130 aircraft give the scientists the opportunity to operate at field camps, and the use of helicopters and contract fixed-wing aircraft, primarily Twin Otters, allows close air support to field parties.

The transition of the LC-130 aircraft to the Air National Guard, in my view, has a couple of important things. We've heard about the single-point management ski-equipped aircraft. It also makes available, on relatively short notice to the operators both in the Arctic and the Antarctic, C-130 aircraft that might be used or can be used to support activities where ski-equipped aircraft are not required. For example, in one of my visits to the Antarctic Peninsula, the hop from Punta Arenas, Chile across to the King George Island was in a wheeled New York Air National Guard aircraft which was very satisfactory because you didn't need ski-equipped aircraft for that particular mission.

The question about international collaboration raised in the NSTC report, I think those of us who are active scientists know that international collaboration on most scientific activities begins on a scientist-to-scientist basis and builds from the bottom up, and the most successful of these international activities begins on an informal basis and then are translated into bilateral or multilateral collaborative efforts worked out between the managers of Antarctic programs.

It struck me to design a station with a setaside area for international activities is simply wrongminded, and we ought to establish a base where those kinds of activities can take place. We see aircraft, ships and station support that are both provided to and provided by the U.S. to support science. For example, many parties working in the TransAntarctic Mountains have in the past been supported by helicopters from the Italians or from the Germans and aircraft are being used by U.S. scientists that have come from the British Antarctic survey. There is a very, very good mix going on and more and more is becoming cost reimbursable activity, and in my view that this type of collaboration ought to be encouraged in the future.

Finally I would simply say that having been involved with this business now for long years I think the quality of Antarctic research is excellent, it continues to improve, and I personally am proud of the leadership role of the United States Antarctic Program in working with all of the Antarctic Treaty nations to collaborate and to improve the overall quality of science programs being carried out in and around Antarctica.

Thank you.

Mr. CRAMER. Dr. Rutford, thank you.

Dr. Clark.

STATEMENT OF DR. DAVID L. CLARK, CHAIRMAN, POLAR RESEARCH BOARD, NATIONAL RESEARCH COUNCIL/NATIONAL ACADEMY OF SCIENCES

Dr. CLARK. Thank you.

First I would like to tell Mr. Gutknecht that in answer to your question about 70 percent of the world's fresh water that Dr. Sullivan only partially answered your question. You probably thought the other 30 percent was in Minnesota. Actually it's shared by Wisconsin and Minnesota and part of Greenland as well.

One other correction for the record, Mr. Chairman. I am not the Chairman of Department of Geology and Geophysics as it states. I'm a former Chairman of that Department, but I'm Chairman of the Polar Research Board of the National Research Council.

As you're probably aware, the National Research Council is the operating arm of the National Academy of Sciences, and the Polar Research Board was created about 40 years ago primarily to support Antarctic research at that time, or not to support it, but to give advice to government agencies concerning matters of policy on science and technology for either of the polar regions, but at that time in 1958 primarily for the Antarctic region.

Since that time the Polar Research Board's interests of course have expanded. We now include a sizeable amount of expertise for the Arctic regions as well, and more recently we have become the U.S. National Committee for the international science involvement in both the Antarctic and the Arctic, and the delegates, the official U.S. delegates to both of the International Science Committees for these polar regions are members of the Polar Research Board.

The polar regions of course support interdisciplinary studies that involve matters not only of growing public concern but as well basic research. I think it's important to understand that not only are the physical, biological and social systems of high latitudes especially tightly wed, but also the polar research communities had a long and strong tradition of bringing together diverse groups of scientists to work on very complex problems whose solution required the pooling of expertise. In this sense I think polar research offers a model for an approach to the conduct of science that is destined to become increasingly important and central to the study of large-scale environmental issues in the coming years.

The National Science and Technology Council report includes excellent examples of why Antarctic research is important. I hope that your Committee keeps in mind the fact that Arctic research is also important for all of the same reasons that are included in this particular document; that is, bipolar processes affect people, they affect human welfare at lower latitudes and the Arctic regions and the Antarctic regions. The polar regions, I should say, provide a location and conditions that are absolutely unique for certain scientific studies, many of these referred to by Dr. Sullivan. These are the similarities, and there are other similarities of course in snow and ice. Dr. Sullivan also pointed out the differences, that the Arctic is primarily an ocean surrounded by land, whereas the Antarctic is primarily a land surrounded by an ocean.

In the last few years there have been significant changes to polar research, many of them introduced because of significant changes in the political scheme of the world. We now have sources of information both from the U.S. and from the former Soviet Union on various polar matters, information that was not available previously.

All of this information isn't good. In the Arctic, for example, we now have been notified, we have found out, we've discovered that the Soviets dumped excessive nuclear waste material into the Arctic waters, and this has been a matter of concern for peoples in the Arctic region that some of this water pollution could affect their health.

Polar research of course is complex, it's difficult and it's expensive, and yet it has a unique contribution because many of the processes that are taking place in the polar region today have the possibility, and not only the possibility, but they actually do affect human populations.

As far as the U.S. is concerned, our more important concern for peoples is in the Alaskan area where the Arctic region, things such as Arctic haze, the diminishing of the ozone insulating layer which was first noted in the Antarctic and now has been noted in the Arctic, and a number of other factors, including the pollution of polar water masses that can affect people make these things very important.

As far as basic research is concerned, there are also a number of important things that cannot be done anywhere else, and all of these have been referred to here today—astrophysical work, the environment for doing these kinds of things, various aspects of physical oceanography, the heat budget for the world, the fact of the circulation around the Antarctic and the contribution of the Arctic mass to the North Atlantic. All of these things in terms of climate changes, and even individual weather patterns change yearly because of the extent of the ice cover in the Arctic region, and all of these are areas of sort of basic research which may have human applications as well.

You have my written testimony, and I can only add really that because of the complexity, the difficulty, the logistical problems and the expense of doing polar research that a continuing examination of research priorities and technologies and their deployment should be remain a national priority. This is particularly important because of the significance of the fact that what happens in the Arctic and the Antarctic not only affects people, but it also is an area where we may learn a great deal about our earth, about our solar system and even our universe which we can't learn any place else.

I hope that these kinds of things together with the fact that polar research is really an interdisciplinary research activity impresses your Committee and justifies your continued support.

Thank you.

[The prepared statement of Dr. Clark follows:]

FUTURE OF ANTARCTIC RESEARCH

Testimony of
Dr. David L. Clark
Chairman, Polar Research Board
National Research Council/National Academy of Sciences

before the
House Committee on Science's Subcommittee on
Basic Research
U.S. House of Representatives

July 23, 1996

Mr. Chairman, I appreciate the opportunity to discuss the significance of polar research with your committee, and to comment on the National Science and Technology Council's report on the importance of the U. S. Antarctic program.

I am David L. Clark, professor of geology and geophysics at the University of Wisconsin-Madison. I also serve as Chairman of the Polar Research Board of the National Research Council. As you are aware, the National Research Council is the operating arm of the National Academy of Sciences, National Academy of Engineering, and Institute of Medicine. The Polar Research Board was established by the National Academy in 1958 to advise government agencies on matters of science and technology related to both the Arctic and the Antarctic. Our Board also serves as the National Committee for U. S. involvement in international polar science affairs. The U. S. delegates to both the international Antarctic organization (Scientific Committee on Antarctic Research or SCAR) and the international Arctic organization (International Arctic Science Committee or IASC) are Board members.

NSTC Report

First, I refer to the National Science and Technology Council Report on the U. S. Antarctic program. This is a comprehensive and accurate review of the USAP history and importance, plus an overview of a few of the ongoing research projects. Because of the complexity of polar research, a continuing reevaluation of priorities and directions is necessary. The NSTC report provides a good beginning to this reevaluation and outlines some of the scientific and political problems that must be addressed as we consider the relative benefits and costs of the U. S. research effort in the Antarctic.

At a time of austerity, science must tighten its belt along with the rest of government supported endeavors. But we should note that polar science is somewhat of a special case, at least in part, because unlike some of the federal programs where improved management or a different organizational structure can meet the challenge of a reduced budget, polar research is already efficiently managed. In addition, there is no other source of support for this difficult and expensive activity which is clearly important to the national interest. The benefit of understanding how polar regions are 'ikely to affect mankind may even argue for an expanded rather than a more limited role ›r polar research in future budget considerations.

Bipolar research, that is, research in both North and South Polar regions, is important for a number of reasons. It is important because polar areas have high rates of change in their physical and biological systems that can result in environmental alterations that will affect Earth and people at lower latitudes. The extent and durability of the polar ice-covers and their relationship to climate and sea level rise, global warming, ozone depletion, Arctic haze, and perturbations of the chemical and physical makeup of polar waters are some of the most important subjects of concern. The impact of these factors on people is necessarily most pronounced in the Arctic but we should be aware that the impact also affects Earth's inhabitants at lower latitudes. Bipolar research is difficult and expensive because of the climate and physical environment of polar regions. The hostile polar conditions restrict many kinds of research to brief periods of time. Additionally, logistical support for high latitude work is complex and expensive. The U. S. has developed a good research support system, but even this excellent U. S. effort has not resolved all of the problems.

The Value of Bipolar Research

One of the biggest problems for bipolar research is that we haven't solved the puzzle of identifying the natural variation inherent in many of Earth's systems so that we can clearly identify which Earth changes are caused by human activity and which are the result of normal Earth variability. This is important because some of the changes produced either naturally or by civilization could alter Earth's climate, a change that ultimately will affect the health, safety, and well-being of all of Earth's inhabitants.

In addition to the factors that affect people in the polar regions as well as at lower latitudes, there are important components of what might be called basic polar research. While polar science literally ranges from A to Z (Astronomy to Zoology), certain areas of astronomy, atmospheric sciences including climate, the biosphere, the geosphere and cryosphere, and the marine sciences have received most attention. Here are just a few of the scientific issues that make basic polar research unique.

Astronomy

Astrophysical research is important for reasons ranging from a need to understand the structure and origin of the universe to monitoring yearly changes in solar radiation. In the polar regions:

- Astronomical objects are continuously observable at constant or nearly constant distances from Earth.
- The atmosphere is unpolluted, at least in the Antarctic, and extremely dry, resulting in high transparency. The low water-vapor content of the Antarctic Plateau is the best place on Earth for far infrared and submillimeter astronomy,
- At many wavelengths, the sky is exceptionally dark, both because of the absence of man-made sources of light pollution and, in the infrared range, because of reduced thermal emission,
- Conditions of continuous darkness or light, coupled with a relatively stable large-scale atmospheric circulation pattern, promote long periods of consistent observing conditions,
- The open topology of the polar geomagnetic field allows observation of less energetic cosmic rays than is possible at low latitudes,

- The polar icesheet contains vast quantities of pure ice that can potentially be used as a large-area detector for Cherenkov radiation from neutrino-induced interactions.

Atmosphere and Climate

Atmospheric studies in the polar regions have identified a number of factors that are important for basic research and for human health. For example, tropospheric research involves the study of the exchange of heat and chemical reactions among rare gases between ocean water and the air as well as the concentration of particulate matter. This is important for Arctic people because of the relationship of all of this to Arctic haze, the tendency for pollutants generated in lower latitudes to move to the Arctic and accumulate.

Stratospheric research is of great significance because it contains a relatively high concentration of ozone gas, the so-called ozone layer. The reduction in the thickness of the ozone layer was first observed in the Antarctic stratosphere but a similar phenomenon is now recognized in the Arctic stratosphere. Because a thinner layer of ozone absorbs less ultraviolet radiation, humans exposed to the radiation are at risk for cancer and cataracts. In addition, organisms living in the upper ocean waters can be damaged. We think we know at least part of the reason for the thinning of the ozone layer, and it is related to human activity and the use of chlorofluorocarbons. The same chemicals in the oceans and even the troposphere pose no problem, but in the stratosphere, especially in the Arctic, the thinning is a matter of considerable importance.

Mesospheric research is more involved with the solar-terrestrial relationships and the physics and chemistry of the upper atmosphere and plasma field particle environment that surrounds Earth.

Also, there are questions related to the surface energy balance of the Arctic and Antarctic and to the processes that alter the energy balance. We need to have an understanding of precipitation patterns over both Antarctic and Arctic and the possible consequences of a warmer climate on Earth's ice-budget.

Biosphere

Research on polar organisms and their interactions with the environment cover a wide range of disciplines and employ a vast array of technologies, scientific equipment, and logistic support. Continuing and emerging issues that arise from biologic research include:

- How do flora and fauna adapt to polar conditions?
- What can be done to lessen the human impact on polar ecosystems?
- Which polar species are indicators of environmental change?
- What can we learn from the fossil and genetic records of polar organisms that may be beneficial to humans?

Geosphere and Cryosphere

The geologic development of bipolar geosphere and cryosphere is only partially understood. Issues that need attention include:

- To what extent are climate change histories expressed in sediment and ice-cores applicable to models for future global change scenarios? Are changing conditions in the polar regions the triggers for worldwide change, or do the polar regions respond to triggers related to other factors?
- What is the current mass balance of ice-sheets and how will the mass balance change due to global warming?
- Are recent changes in the size of fringing ice-shelves of the Antarctic Peninsula due to known warming trends, and, if so, are these trends related to natural climate cycles oranthropogenic factors?
- What is the true distribution of clathrates in the Arctic? Are there ways of utilizing this extensive resource for humans?
- Is the natural variability in the climate system now known from the Arctic (Greenland ice-cores) reflected in the Antarctic?

Marine Sciences

Oceanographic research in the Antarctic is more advanced over that in the Arctic because of the existence of two ships dedicated to Antarctic marine studies, whereas no ship dedicated to deep Arctic research is available. Because of this, U. S. marine studies in the Arctic ocean are limited to a few cruises on Coast Guard icebreakers and work from floating ice-stations.

In physical oceanography, major problems requiring attention over the next decade relate to the role of the high-latitude oceans in the global thermohaline circulation and its variability, and the interaction between the ocean and the Antarctic ice-shelves and the Arctic sea ice-cover. In order to address this, we need to ascertain the natural variability of high-latitude oceans, determine the mechanisms by which the polar shelves and the deep ocean are coupled, understand the processes controlling high-latitude circulation and mixing, and study regional circulation patterns and their role in distribution of water.

Biological oceanography, briefly referred to in the Biosphere section, is concerned with understanding the organisms that occur in polar regions and their ecosystems. A number of ongoing programs have been designed to address issues of global flux and global ocean ecosystems dynamics. Ultimately, we must understand the role of polar oceans in Earth's carbon flux and the role that the increasing levels of carbon dioxide play in global warming.

Geological and chemical oceanography research in the polar seas has only recently begun to yield answers to questions of polar Earth structure and ocean chemical fluxes and their cycles. We still do not understand how the largest part of the deep Arctic Ocean (the Amerasian Basin) formed? Perhaps the largest unknown geologic structure on Earth is in the Arctic Ocean, the Alpha Ridge. The Alpha Ridge is larger in area than the Alps, and a knowledge of its structure and origin are vital to understanding the entire western Arctic Ocean. Also important is whether the modern polar climates are a result of geologic factors that influence atmospheric and water circulation, or if the polar climates are the result of astronomical factors unrelated to the tectonic development of the high latitudes.

Summary

The polar regions offer exceptional opportunities for interdisciplinary studies involving matters of growing public concern as well as basic research. The physical, biological, and social systems of the high latitudes are tightly wed, and the polar research community has a long and strong tradition of bringing together diverse groups of scientists to work on complex problems. Thus, polar research offers a model for an approach to the conduct of science that is destined to become increasingly central to the study of large-scale environmental issues in the coming era.

The Exxon Valdez oil spill demonstrated the need for interdisciplinary science and the role research can play in supporting the nation. Advice had to be given to local residents on the safety and risks to the food chain from the widespread contamination following the spill. Information needed for this task spanned a wide variety of scientific disciplines, state and federal agencies, and academic institutions. Data were needed on the biochemistry and toxicology of the components of crude oil, on the benthic environment, and on the food chain. Data on all animal species were needed, not only to predict the likelihood of bioaccumulation that could result in levels harmful to the human consumer, but also to enable predictions about the potential impact to each individual impacted species. Early-on, knowledge was inadequate about what chemicals to monitor, in what species, in what organ or tissue, and how to sample. Few data were available as a baseline against which detected levels could be compared. The necessity of responding brought together many agencies in an ad hoc Oil Spill Health Response Committee and an expert toxicology committee. The combined expertise of many scientists provided key insights that helped to guide response efforts and to formulate public policy.

In Antarctica, the quest for a better understanding of those factors that regulate ice-sheet stability has brought together glaciologist, atmospheric scientist, earth scientist and physical oceanographers. This collaboration is essential in evaluating the potential for ice-sheet collapse and associated rapid sea-level rise. A byproduct of this collaboration is improved understanding of the coupling between the ice-sheet, the bedrock on which it rests, climate change and physical oceanographic influences on ice-sheet and ice-shelf stability.

To the non-polar scientist, it would appear that scientific study might be much the same in north and south polar regions. Both the Arctic and Antarctic face extremes of temperature, length of days and nights, the presence of large amounts of ice and snow, plus the difficulties of access and transportation. But there is also much that is different in conducting work in the Arctic and the Antarctic. Transportation and field stations for survival, organization of national science programs, presence or absence of humans and traces of their politics and civilization, patterns of snow and ice distributions, and animal life all are quite different in the two polar regions. Because of this, the differences in priorities and planning for research in the northern and southern polar areas are significant.

Social changes in the native communities of the North also are forcing new evaluations of research priorities with respect to the role that people play in Arctic research and development. The indigenous inhabitants of the polar regions now have a realistic expectation that science conducted on their traditional lands should respect their cultural needs and values; enlightened design will be needed to maintain both access to the lands and the continuity of their cultural heritage.

Changes in the world's political systems are influencing research directions. At this time we are unaware of where these changes may lead, but they have already had dramatic effect on polar research. The dismantling of the USSR has brought about changes with respect to access to data and facilities in both the Arctic and the Antarctic. This change alone has caused shifts in the balance of the programs in the international Antarctic community, has enabled formulation of new multilateral organizations for cooperation in Arctic science, and has allowed international access to important bodies of data. The availability of previously classified data and technology from both the former Soviet Union and the U. S. reflects the end of the Cold War. Unfortunately, all of the data that have become available are not good news. We have learned of possible ecological damage wrought in the former Soviet Union that has the potential of affecting the condition of Arctic lands and seas into the future. The technology of Arctic environmental cleanup will be severely tested under the harsh conditions of polar regions, whose sensitivity to such insults is well known. Similarly, the long range of effects of ecologic contamination, if any, on the Antarctic will shortly be defined.

The technology available for collecting scientific data has undergone dramatic development. For example, the widespread availability of computer systems and the advent of satellite-link information-gathering systems for both the physical and biological environment have created significant new data bases. Polar-orbiting satellites and space shuttle missions have provided an abundance of space-based photography that can document changes or provide information in areas inaccessible on short notice. The development of these technologies has been more important to data acquisition in the polar regions than in more temperate parts of the world because of the remoteness of the polar areas and the difficulty in working in these extreme environments. Technology will continue to improve as new instrumentation and methodologies are developed.

It is essential that research in the polar regions keep pace with these developments. A continuing examination of research priorities and technologies and their deployment should remain a national priority, particularly in the polar regions. The NSF, NOAA, NASA, ONR, USGS, and DOE, agencies with important polar interests, should be commended for helping the U. S. maintain leadership in polar research. The peaceful use of Antarctica, in particular, is dependent on this leadership.

Mr. CRAMER. Thank you very much for your testimony.

I'll begin my five minutes now and invite both of you to respond to this though I may direct it at one or the other.

Dr. Rutford, what priority would you assign to rebuilding the South Pole Station? Now in my opening comments, if you were here in the audience, and I don't remember if you were, but from your remarks I gather you were, I said this is a tough budget atmosphere and we're a little perplexed as to where money is going to come from and what priorities we should put there. So when I say what priority would you assign to rebuilding the South Pole Station that is within the context of a fixed budget for the Antarctic Program.

Dr. RUTFORD. Well I think it's very clear that if you maintain the budget for the Antarctic Program at this level, that the ability to rebuild the South Pole Station is basically out of the question.

When I was the Director of the Division of Polar Programs in the mid-'70s, we essentially shut down science in Antarctica for one year because of a glitch in the transfer of funds at the time when the transfer of DOD funds into the NSF budget somehow got goofed up in the process.

Mr. CRAMER. I guess part of what I'm asking is should we divert funds from research in order to do this? That's tough, isn't it?

Dr. RUTFORD. It's a tough question and again one that I think depends upon who you ask. If it impacts on a person who has got some graduate students involved and is not involved in the South Pole Station they will probably give you one answer. I would hope that the Antarctic community is sophisticated enough now to look at a little bit bigger picture, and in fact it may result in the diversion of some funds for a period of time in order to maintain that program.

I would hope, however, that the Congress, even in this very difficult budgetary environment, and I mean I would like to argue with somebody that, you know, $200 million probably drops through the crack every day some place, and what we need to do is to find out where that's dropping and sweep it up a little bit and give it to the Antarctic Program.

[Laughter.]

Mr. CRAMER. Well we could use your help with that as strange as that might sound.

Let me take this one more step. Would you recommend building an international station as a replacement for the current pole station?

Dr. RUTFORD. No, I would not. I would think that it's a place where international activities should occur, and it's a place where other nations could conduct research at that point, but the management of that activity needs to be within the U.S., and it needs to be a clearly stated U.S. activity at the South Pole.

I guess my view on it, having been involved in Antarctic Treaty negotiations over the years, is that if the U.S. were to walk away from South Pole I would guess you would have three airplanes landing from three different bases the next day, and the stability that we now have under the Antarctic Treaty would be very, very different than it is today.

Mr. CRAMER. Dr. Clark, is there unnecessary overlap between Antarctic and Arctic research activities?

Dr. CLARK. No, not really. As I say there are many similarities, but there are also many differences. Traditionally the Antarctic has been supported to a greater extent than the Arctic as far as research activities are concerned. The gap is narrowing now thanks primarily to the NSF's new Arctic programs and the various things they've instituted in the last five or six years, but some of the problems that can be studied are very different.

I think specifically of astrophysical problems. The South Pole astrophysical observatory, for example, allows observations of celestial objects at more or less a uniform distance primarily because instead of moving about at about 1,700 kilometers an hour as the earth is moving from west to east at the equator, at the pole theoretically we're not moving nearly as fast except for the whole earth moving from the sun.

There is currently a program observing the sun's vibrations over a 24-hour period, during the Antarctic summer of course, and the very location of that could not be done in the Arctic region for reasons that Dr. Sullivan mentioned because it's floating ice and within the Beaufort Gyre this ice is constantly moving. One of the reasons people have had a hard time, explorers and adventurers, reaching the North Pole is because it's not a stable pole such as the South. So there are very different things that are done in the polar regions, and I am not really aware of any overlap in the programs.

Mr. CRAMER. Well given your experience with both, are there are more important research opportunities in one region or the other that are not being pursued?

Dr. CLARK. Well this gets really into logistics. The logistical support really for Antarctic research has been in place for a number of years by a mandate and has been furnished by the National Science Foundation. They are now looking at furnishing the same sort of logistical support for the Arctic, which the Arctic has never had, and consequently I would have to say there are many things, perhaps more things that are left undone now in the Arctic than in the Antarctic, but as NSF reorganizes and addresses some of these problems, as they have promised they are going to, I suspect that this gap will be cleared up fairly quickly.

Mr. CRAMER. All right. Thank you both.

Mr. Gutknecht.

Mr. GUTKNECHT. Thank you, Mr. Chairman.

You've asked most of the questions I was going to ask. So I don't have a whole lot left to ask. But I do want to come back to something Dr. Clark talked about.

I had always heard that, and this really doesn't relate to the Arctic or Antarctic, but it does relate to Minnesota and Wisconsin, that something like five percent of the fresh water is in the lake which is shared between Minnesota and Wisconsin, Lake Superior. Is that true?

Dr. CLARK. I don't know whether it's five percent or four and a half, but that's very close, yes. Between Greenland and the Great Lakes and then all the lakes in Wisconsin and Minnesota you have most of the rest of the fresh water on earth.

Dr. RUTFORD. Most of them in Minnesota of course.

[Laughter.]

Mr. GUTKNECHT. Well I was in Northern Wisconsin last weekend and it was just beautiful up there.

I don't have any other questions. I think just to restate what has been said before, I think there is general support on this Subcommittee and on this Committee for the continued research in the Antarctic, but we are facing sort of a zero-sum game as we go into the future, and I think that that's going to require more creativity and more cooperation between the various entities that are involved down there. We appreciate the work that you do, but we would even more appreciate any help or advice you can provide us with how we can get absolutely every mile out of every dollar that we have to spend because it is becoming difficult.

As I said, I think the Chair of this Committee and the Chair of the Subcommittee on a bipartisan basis I think work to try and squeeze as many dollars as we can for research projects. But I can tell you as we go forward that's going to become increasingly more difficult because, just for your information, we have to find I believe to meet our budget goals something like $43 billion worth of additional budget cuts in three years. You know, everybody likes to talk about balancing the budget in general, but when you start getting down to the specifics that means real programs like this one.

So I would encourage you to work together with your colleagues and help us where you can to look for ways that we can cooperate and work together, but thank you very much for appearing today.

Mr. CRAMER. Ms. Morella.

Ms. MORELLA. Thank you.

I am a great lover of Antarctica. I wish I could have been here earlier. I'm curious and I would just ask one question because those who get here late should not be afforded an abundance of time to keep others waiting.

I note that I think the National Science Foundation is going to set up another advisory board. I was in Antarctica and I remember seeing the plans about how they change from, the South Pole Station plan, from one to another to another, and it went on and on and on. If we had just done some building early on we might have saved a great deal of money and have the new South Pole Station.

At any rate, I understanding that the National Science Foundation is going to set up a new advisory board with Norm Augustine who is one of my constituents heading it. Will they be working with the National Academy of Sciences? What have you heard about it from your perspective? Will there be integration in terms of the crafting of whatever report comes from that advisory board?

Dr. CLARK. We have talked to Dr. Sullivan about this. The Polar Research Board certainly stands ready to accept any invitation to participate in this particular board. He has created this board to examine the Antarctic question based on I guess some other criteria than the need for the NAS to be involved, and we have not been greatly involved in the planning other than being aware that this is being set up. And I guess I couldn't say anything additional, except to tell Dr. Sullivan the Academy certainly stands ready to assist in any way they could.

Ms. MORELLA. Do you agree, Dr. Rutford?

Dr. RUTFORD. I think Dr. Clark has expressed the situation quite clearly. At least to the best of my knowledge, the Polar Research Board has not been approached for advice on members of the committee or for advice with regard to the study.

Ms. MORELLA. Maybe it's something that this Subcommittee could do, you know, could just say we hope that you're coordinating and using the advice and counsel.

Dr. RUTFORD. Well I think it's clear that there will be input from individuals, but at least at the present time there will not be a formal involvement of the Polar Research Board.

Ms. MORELLA. I know this has probably been answered. I know that Mr. Cramer asked a question rather similar to the idea of what kind of priority do you place on rebuilding the South Pole Station within the context of a fixed budget. If you were in our situation what kind of priority would you place on it? Do you think it needs to be done now?

Dr. RUTFORD. Well that is an extremely tough question because I think you have to put it not only in terms of the question of the Antarctic research program, but you have to put it into context of the overall research activities that NSF supports. In the past, NSF has gotten into difficulty by sometimes making commitments for major investments in equipment or in facilities in a relatively stable funding environment that resulted in them having to, you know, kind of patch up to get the job done.

One of the critical things I think is if you're going to look at the South Pole Station, or if the Division of Polar Programs looked at the South Pole Station that's one thing, and they could say you can establish a priority and say well that's priority No. 1 and that's where a majority of our equipment money ought to be go for the next year or the next six or seven years, that the transfer of the LC-130s into the Air National Guard will delay the need to replace them for six or eight or ten years, however long that is that they're able to operate, and so you take the equipment money and you put that into the South Pole Station over the next eight years.

NSF needs to look at from the overall science view as to what is the priority in terms of competing equipment money. As I understand the budget these days, there is MRE money or something like that which is kind of an overall pot for equipment and facilities within the National Science Foundation budget. So it's a difficult call.

I personally, I guess, think that it's very important that we maintain a viable South Pole Station both for political and for scientific reasons, and therefore I think that the priority that needs to be assigned to it is pretty high.

Ms. MORELLA. Do you agree, Dr. Clark?

Dr. CLARK. I would certainly agree with that. If I were put in the position of having to say which research programs might suffer so that the South Pole Station could be built I of course would go outside of the polar programs.

Dr. RUTFORD. Arctic marine geology of course.

Dr. CLARK. No.

[Laughter.]

Yes, that would be difficult, but nonetheless it has to be done even if some other research has to be delayed while it's done or else the whole program will suffer.

Ms. MORELLA. A good answer.

Thank you, Mr. Chairman.

Mr. CRAMER. Thank you. It is a tough question and we don't necessarily have the answers either, but we've got to struggle through that and that's why we're asking for your input.

This concludes the testimony. Thank you, Dr. Rutford, and thank you, Dr. Clark. Thank you both, and I thank the other witnesses as well.

We will leave the record open so that other questions and testimony may be submitted for the record. Thank you.

The hearing is adjourned.

[The Committee adjourned at 4:05 p.m., subject to the call of the Chair.]

[The following material was received for the record:]

Executive Office of the President of the United States

United States Antarctic Program

Committee on Fundamental Science

National Science and Technology Council

April 1996

About the National Science and Technology Council

President Clinton established the National Science and Technology Council (NSTC) by Executive Order on November 23, 1993. This cabinet-level council is the principal means for the President to coordinate science, space, and technology policies across the Federal Government. NSTC acts as a "virtual" agency for science and technology to coordinate the diverse parts of the Federal research and development enterprise.

The NSTC is chaired by the President. Membership consists of the Vice President, Assistant to the President for Science and Technology, Cabinet Secretaries and Agency Heads with significant science and technology responsibilities, and other senior White House officials.

An important objective of the NSTC is the establishment of clear national goals for Federal science and technology investments in areas ranging from information technologies and health research, to improving transportation systems and strengthening fundamental research. The Council prepares research and development strategies that are coordinated across Federal agencies to form an investment package that is aimed at accomplishing multiple national goals.

To obtain additional information regarding the NSTC, contact the NSTC Executive Secretariat at 202-456-6100.

About the Office of Science and Technology Policy

The Office of Science and Technology Policy (OSTP) was established by the National Science and Technology Policy, Organization, and Priorities Act of 1976. OSTP's responsibilities include advising the President in policy formulation and budget development on all questions in which science and technology are important elements; articulating the President's science and technology policies and programs, and fostering strong partnerships among Federal, State, and local governments, and the scientific communities in industry and academe.

To obtain additional information regarding the OSTP, contact the OSTP Administrative Office at 202-395-7347.

AD HOC WORKING GROUP ON THE U.S. ANTARCTIC PROGRAM

Committee on Fundamental Science
National Science and Technology Council

France Cordova
National Aeronautics and Space Administration

Sidney Draggan
Environmental Protection Agency

Karl Erb
National Science Foundation

Jack Fellows
Office of Management and Budget

Gerald Garvey
Office of Science and Technology Policy

Walter Hays
U.S. Geological Survey

Sarah Horrigan
Office of Management and Budget

Thomas Lovejoy
Smithsonian Institute

Bonnie McGregor
U.S. Geological Survey

Ernest Moniz
Office of Science and Technology Policy

Edward P. Myers
Department of Commerce

Emily Pelton
Office of Science and Technology Policy

Joseph Sestak
National Security Council

Bradley P. Smith
Department of Defense

R. Tucker Scully
Department of State

Alan Summy
United States Coast Guard

Stephen M. Wheeler
United States Coast Guard

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Executive Summary

Introduction: Antarctica, with 10% of Earth's land mass, is nearly 1.5 times the size of the United States. Its associated seas represent nearly 6% of the world's oceans and its ice, 70% of the Earth's fresh water. The United States has important foreign policy, national security, scientific, and environmental interests in this vast area. A strong year-round presence in Antarctica, in the form of cutting-edge scientific research supported by infrastructure at three research stations, is the principal means of realizing these interests. The Amundsen-Scott Station at the South Pole is of particular importance in this regard, but its buildings and associated life-support systems are nearing the end of their design life and are in need of replacement. The estimated cost of replacement is substantial, and this, combined with current and anticipated budget constraints, raises important issues concerning the U.S. Antarctic Program, or USAP. In particular, the Senate Appropriations Committee expressed concern over the costs of the USAP, questioned whether the existing policy to maintain a presence in Antarctica is still valid, and called for the National Science and Technology Council to undertake a Government-wide review of that policy and to examine options that can reduce the annual operating cost. This document reports the results of that review.

Policy Issues: The United States has important foreign policy and national security interests in Antarctica. These interests are given concrete expression through the Antarctic Treaty of 1959. The Treaty guarantees freedom of scientific research in Antarctica and prohibits military and nuclear activities there. Further, it includes imaginative juridical and decision-making provisions that defuse potentially explosive disputes over sovereignty in Antarctica among its Parties.

The international peace and political stability in the area resulting from operation of the Treaty are themselves important policy objectives of the United States. Moreover, the Treaty is the indispensable basis for successful pursuit by the United States of the unique opportunities Antarctica offers for scientific research, as well as associated goals of protecting the pristine environment of Antarctica and conserving its resources.

The success of the Antarctic Treaty and the achievement of U.S. Antarctic interests are the direct result of the active and influential U.S. presence in Antarctica maintained by the United States Antarctic Program. This year-round presence protects the U.S. position on sovereignty in Antarctica and accords us a decisive role in the Treaty's activities-based decision system, both of which are essential to maintaining the political and legal balance that makes the Treaty work. *Thus, from a policy perspective the NSTC finds that maintaining an active and influential presence in Antarctica, including year-round operation of South Pole Station, is essential to U.S. interests.*

The U.S. Antarctic Program: U.S. activities in Antarctica, the region south of 60 degrees south latitude, are managed in a single integrated program — the USAP — that adheres to the principles of the Antarctic Treaty of 1959. Overall program responsibility for these activities was transferred to the National Science Foundation in 1970, as formalized in National Security Council Memorandum 71, and in 1976 NSF was assigned responsibility for single-point management of the entire program. In 1982 the President reaffirmed in PM6646 the national policy underlying the USAP and directed that the Program be maintained at a level providing an active and influential presence in Antarctica, including year-round occupation of South Pole Station and two coastal stations. At present, NSF budgets $196 million annually to provide the infrastructure and operational support required for research in Antarctica and to fund a broad spectrum of scientific activity on the continent and surrounding oceans. The Program operates three strategically located research stations on the continent, as directed by the 1982 Presidential Order, as well as two research vessels employed in studies of the surrounding oceans and ocean floors. The ships also provide logistic support for Palmer Station. *The NSTC review found that the National Science Foundation has implemented U.S. policy in an effective manner, especially by substantially improving environmental stewardship, by broadening the science program, and by privatizing some operational elements of the Program to reduce costs.*

USAP Research has three principal thrusts: Understanding the Earth and its large-scale systems, with particular emphasis on probing Antarctica's influence on these systems; research for which Antarctica is an ideal platform, such as studies of the universe made possible by the unique conditions for astronomy at South Pole Station; and exploration of the geographical frontier. Of immediate relevance is the research investigating changes to the global environment and the potential consequences of these changes. Each of the three stations (McMurdo, Palmer, and Amundsen-Scott at the South Pole) and two research vessels provides unique research opportunities needed for major advances in many fields of science. At present, U.S. scientists from 26 different states are engaged in the Program. *The NSTC finds the USAP research program to be of very high quality and of great interest to a broad scientific community.*

Budget and Support Issues: As a government-wide program, the role of the USAP expenditure should be judged against the Federal research portfolio. The current annual investment in the USAP is less than one percent of the total federal investment in basic and applied research. This level provides for substantial progress in the three major scientific directions noted above as well as a cost effective scientific return to our total investment. About 60% of the USAP funds provides the U.S. presence and logistic support needed to operate the science program in the uniquely challenging Antarctic environment. This logistic support also provides the necessary infrastructure for all federal agencies carrying out research in Antarctica. *The NSTC believes that, at the current level of investment, the USAP is cost effective in advancing American scientific and geopolitical objectives and, from a science perspective, supports the continuation of three stations with year-round presence.*

The NSTC recognizes that maintaining the high scientific value of the program in the face of budgetary uncertainties places a high premium on detailed understanding of options for cost reductions. This report describes anticipated savings from further management efficiencies and discusses possible program retrenchments and the associated scientific losses. A specially constituted external panel should be established. This panel should be free to examine a full range of infrastructure, management, and scientific options, including reductions in scope commensurate with a range of budgetary scenarios. A 5- to 7-year freeze in total USAP funding (including South Pole Station construction) is one of the options to be analyzed by this panel. Timely input to the budget process, starting with the FY98 budget, is highly desirable. *The NSTC recommends that an external panel be convened by NSF to explore options for sustaining the high level of USAP science activity under realistic constrained funding levels.*

South Pole Station: The NSTC reaffirmation of U.S. policy, including the need for a continuing U.S. presence at the South Pole, implies that by the time the Amundsen-Scott Station at the South Pole reaches the end of its useful life, it will need to have been rebuilt or replaced. NSF has been planning for the South Pole Station for some time. In the new budget environment, the plans will benefit greatly from further cost-benefit analyses that examine the trade-offs between the size, lifetime, and capability of the station vs. the anticipated requirements of the science program. It is essential that the cost savings arising from alternative management approaches, remote operation, robotics, and international cost-sharing be explicitly considered. Meanwhile, *the USAP should give highest priority to correcting critical health, safety, and environmental issues at the current station.*

Conclusion: Essential elements of U.S. national and scientific interests are well-served by continued involvement in scientific activity in the Antarctic as carried out by the USAP. The policies laid out in the 1982 Presidential Memorandum 6646 regarding "an active and influential presence in Antarctica," which "shall include the conduct of scientific activities in major disciplines [and] year-round occupation at the South Pole and two coastal stations," continue to be appropriate at the current funding level. The influential presence of the U. S. in Antarctica helps maintain the existing state of international peace and stability on the continent. The science carried out in Antarctica is of great general interest and provides unique and crucial information in several disciplines. The NSTC concludes that present U.S. policy and practice with respect to the USAP are well-justified. Continued substantial progress in management efficiency will be needed to sustain the high level of scientific activity within the anticipated budgetary constraints.

Chapter I
Introduction and Background

A. Reason for Review

For the last 35 years, U.S. policy has consistently called for an active and influential presence in the Antarctic. This presence, implemented through the U.S. Antarctic Program (USAP), is embodied in year-round scientific and support activities on the continent and in the surrounding waters. The National Science Foundation (NSF) manages the $196M USAP as directed by Presidential Memorandum 6646.

In September 1995 the Senate VA, HUD, Independent Agencies Appropriations Committee (Report 104-140) asked the National Science and Technology Council to review U.S. Antarctic policy. As requested by the Committee, the policy review should

> *...examine the validity of the policy contained in Memorandum 6646, namely the need for a year-round presence, the need for three stations, and the roles of the NSF, Department of Defense, and other Government agencies. The review should examine the policy in the context of the value of the science performed in Antarctica and other U.S. interests. Finally, the review should address the affordability of continued U.S. presence in Antarctica in light of the severe budget environment and examine options for reducing annual logistical and operational budget needs. At a minimum, budget saving options should include greater international cooperation, less than a year-round human presence, and closing of one or more of the stations.*

This document provides background information on U.S. Antarctic policy, describes how the United States implements current policy, describes the scientific program of the USAP, discusses options for reducing costs, and sets forth specific recommendations that address the broad policy issues raised in the Senate Committee Report.

B. History of U.S. Involvement in the Antarctic

The first U.S. Government activity in the Antarctic was the United States Exploring Expedition, 1838–1842, which mapped, for the first time, 1,500 miles of the coast. Historians credit the expedition with establishing that Antarctica is a continent.

In this century, Richard E. Byrd's hugely popular, privately financed expeditions in 1928–1930 and 1933–1935 led to Congressional appropriations of $350,000 in 1939 and 1940 for the United States Antarctic Service (USAS), organized as a civilian service under four cabinet agencies. USAS was to establish and continuously occupy bases to be used "in the investigations and survey of natural resources of the land and sea areas of the Antarctic regions." The service was to have had a large scope. However, it was shortened to a single Antarctic winter and two summers because of World War II. The field work in 1939–1941 nevertheless was the largest Antarctic expedition up to that time, and it produced significant discoveries in a number of research disciplines.

After the war the U.S. Navy Antarctic Developments Project (Operation Highjump) in 1946–1947 was by far the largest Antarctic expedition ever, with more than 4,700 naval and marine personnel, 44 observers, 13 ships, and several aircraft. The expedition observed more than 1.5 million square miles of Antarctica, half of it previously unexplored, and took 15,000 aerial photographs. The following season the U.S. Navy Second Antarctic Developments Project (Operation Windmill) used ship-based helicopters to get geodetic ground control for the aerial photographs. The expedition contributed to production of the first medium-scale maps of the region and influenced decisions regarding locations of stations for the International Geophysical Year (IGY) that occurred 12 years later. At a time when other nations had embarked on programs of permanent bases, the U.S. Navy Second Antarctic Developments Project also was a vehicle for continuing the U.S. presence in Antarctica.

In 1954–55 the United States began investigating sites for stations for the IGY, 1 July 1957 to 31 December 1958. The following austral summer it established the McMurdo Sound Air Operation Facility. Of the 65 IGY Antarctic research stations established by 12 nations, the United States operated seven, including the prestigious and scientifically valuable, but operationally challenging, site at the geographic South Pole. The National Science Foundation funded IGY work through the National Academy of Sciences, and the Department of Defense separately funded and provided operational support. International ties strengthened by the IGY, as well as, beginning in 1948, U.S. calls for an international solution to tensions created by territorial claims, led to a meeting in Washington, D.C., in December 1959 at which the 12 Antarctic IGY nations drafted and signed the Antarctic Treaty (see Appendix I), guaranteeing freedom of access for science and other peaceful purposes.

All 12 nations agreed to pursue significant research questions raised during the IGY. The Urgent Deficiency Appropriation Act of FY 1958 provided NSF with $2M for the "post-IGY continuing Antarctic scientific program." NSF established an Interdepartmental Committee for Antarctic Research as well as memoranda of agreement with elements of DoD for operations. The Bureau of the Budget (now OMB) on 3 August 1960 issued Circular A-51, "Planning and conduct of the United States program for Antarctica," directing NSF to "continue to exercise the principal coordinating and management role in the development and carrying out of an integrated U.S. scientific program for Antarctica." The National Academy of Sciences established a Committee on Polar Research (now the Polar Research Board) to provide advice and to establish U.S. representation on the nongovernmental Scientific Committee on Antarctic Research of the International Council of Scientific Unions.

Following the IGY the U.S. Antarctic Program was established. Of the seven stations operated during the IGY the United States closed one, transferred one to Argentina and another to Australia, and continued a fourth with New Zealand until 1973. Byrd Station continued year-round operation until 1971, while McMurdo and South Pole stations remain year-round to this day. McMurdo added research to its IGY role of supporting inland stations, remote camps, and overland research traverses. Biology, geology, and mapping were added to the geophysics disciplines begun in the IGY. In 1965 Palmer Station was established along the Antarctic Peninsula. The research ship *Hero* was acquired in 1968, adding ocean-research capability to the ice-strengthened research ship *Eltanin*, which operated from 1962 to 1972. OMB revised Circular A-51 in 1971 to direct NSF to fund DoD support "on a mutually acceptable reimbursement or nonreimbursement basis." R/V *Polar Duke* replaced the smaller, wood motorsailer *Hero* in 1984, and the new research icebreaker R/V *Nathaniel B. Palmer* in 1992 replaced the *Eltanin*. In addition to the stations and vessels, other improvements included the LC-130 (ski-equipped Hercules) in 1960, intercontinental C-141 operations in the 1970s and C-5s in the 1980s. The 1990s have seen improvements in waste management, operational efficiency, and communications. Research interest in the Antarctic has greatly increased, and the number of each year's field projects has risen from about 35 in the 1960s to 130 in the 1990s.

In 1982 the President, accelerating the process begun with the 1971 revision to A-51, told NSF to manage the Program and to use commercial support if cost-effective and in the national interest. Presidential Memorandum 6646 (see Appendix II) states that the NSF should "budget for and manage the entire United States national program in Antarctica, including logistic support activities so that the program may be managed as a single package." NSF was also instructed to "draw upon logistic support capabilities of government agencies on a cost reimbursable basis." U.S. presence in Antarctica was to include, "year-round occupation of the South Pole and two coastal stations." In August 1995, the National Science Board recommended that "NSF maintain all appropriate logistical capabilities to support the U.S. Antarctic Program, including necessary support from DoD, to sustain active U.S. presence in the Antarctic."

C. Current Scope of the U.S. Antarctic Program

Each year the USAP deploys approximately 2,500 scientists and support personnel to Antarctica and its surrounding seas to support research in many disciplines, including aeronomy and astrophysics, atmospheric chemistry, biology, earth sciences, ocean and climate systems, glaciology, and environmental research. In FY95 and FY96, researchers came from institutions in 26 states and the District of Columbia. (See Appendix III.)

The National Science Foundation funds and manages the following major facilities as an integrated system for the support of research and related activities:

(i) McMurdo Station, the main U.S. facility, on Ross Island, coast of Antarctica (summer population 1,100; winter, 230)

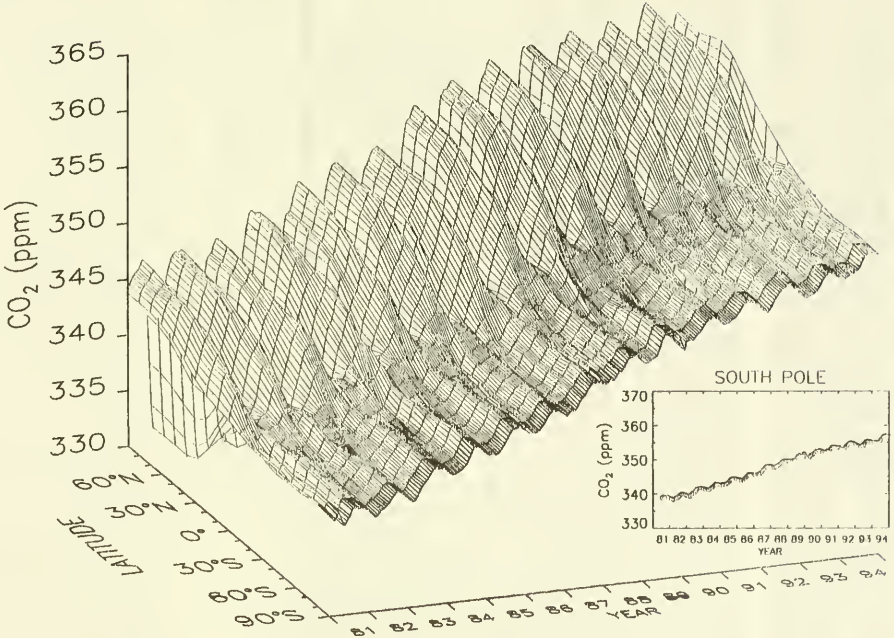
(ii) Amundsen–Scott Station at the geographic South Pole (summer population 145; winter, 28)

(iii) Palmer Station, on Anvers Island immediately west of the Antarctic Peninsula (summer population 45; winter, 10)

(iv) the 219-ft ice-strengthened research ship *Polar Duke* (year-round)

(v) the R/V *Nathaniel B. Palmer*, a 309-foot research vessel with icebreaking capability (year-round)

GLOBAL DISTRIBUTION OF ATMOSPHERIC CARBON DIOXIDE



Three dimensional representation of the global distribution of atmospheric carbon dioxide in the marine boundary layer assuming no variation with longitude. Data from the NOAA/CMDL Global Cooperative Air Sampling Network were used. The surface represents data smoothed in time and latitude. The contribution from the NOAA/CMDL South Pole Observatory flask sampling effort is shown inset as flask monthly means. The 10 degree latitude zone in which South Pole resides is highlighted. Principal investigators: Pieter Tans and Thomas Conway, NOAA/CMDL Carbon Cycle Group, Boulder, Colorado, (303) 497-6678.

The Breathing of the Atmosphere

The total amount of carbon dioxide in the atmosphere results principally from the sum of globally distributed processes such as photosynthesis and respiration in the biosphere, deforestation, and the burning of fossil fuels and biomass. The oceans affect this total by drawing carbon dioxide from the atmosphere and depositing carbon in the bottom sediments.

Precise records of the concentration of atmospheric carbon dioxide are necessary for understanding (1) how it works as a greenhouse gas; (2) how it affects the flow of carbon from the biosphere through the atmosphere to the ocean; and (3) how it induces long-term climatic changes.

The atmospheric carbon dioxide concentration has been measured directly at Amundsen-Scott South Pole Station since the station opened in 1957 at the start of the International Geophysical Year. Since 1975, the NOAA Climate Monitoring and Diagnostic Laboratory has made continuous carbon dioxide measurements at the station as the southern anchor to their global monitoring network (highlighted in red in the diagram).

The diagram shows both the long-term global increase in the carbon dioxide concentration in the general upward tilt of the surface to the right with time and the annually recurring take-up of carbon dioxide by new growth (photosynthesis) in the annual wrinkles of the surface. The reversal of the seasons in the Northern and Southern Hemispheres appears as a 6-month shift for each maximum that occurs near the equator. The much greater variation in the Northern Hemisphere reflects the correspondingly greater land area.

The combined observations that carbon dioxide amounts at South Pole still vary annually and that each maximum follows a coherent yearly pattern show that atmospheric mixing occurs rapidly and that the turbulent mixing and distribution processes are efficient. While other observatories document the background state and chemical composition of Earth's atmosphere, South Pole Station's isolation from large-scale human activity makes it a vital component of the network because results obtained there set a global standard for clean air and are frequently compared to results from around the world.

(vi) a U.S. Coast Guard *Polar*-class icebreaker (399 ft) for icebreaking, channel tending, and supply-ship escort in McMurdo Sound and for additional support and science functions (austral summer)

(vii) Military Sealift Command ice-strengthened cargo and tank ships (one each, once per year) for cargo and fuel delivery to and waste removal from McMurdo

(viii) LC-130 ski-equipped airplanes operated by the Navy and the Air Guard (August and October–March)

(ix) contract operation of smaller (e.g., Twin Otter) research and support airplanes (austral summer)

(x) contract helicopter operations (austral summer)

(xi) specially equipped aircraft, balloons, satellites, and other remote-sensing platforms

(xii) unattended, automated weather stations (50) and geophysical observatories (4)

(xiii) roughly 30 field camps each austral summer placed widely across the continent as required for specific research projects

More information about the science and supporting facilities is in Chapter III. For information on USAP costs, see Chapter IV.

D. Antarctic Activities of Other Federal Agencies

The President's Memorandum also states that, "Other agencies may, however, fund and undertake directed short-term programs of scientific activity . . . . Such activities shall be coordinated within the framework of the National Science Foundation logistics support."

NASA's Antarctic work includes suborbital studies of cosmic radiation and the Sun, study and archiving of meteorites, microbial studies with extraterrestrial applications, sea ice and ice sheet studies, stratospheric measurements related to ozone, a synthetic-aperture radar ground station, technology development (e.g., a food growth and waste recycling system for South Pole Station), and human factors including isolation and confinement and other analog studies; annual NASA funding is about $6M. NOAA funds Antarctic climate monitoring, ozone studies, remote sensing (e.g., sea surface temperature, atmospheric temperature, cloud imagery), sea ice and iceberg analyses, and marine living resources research at about $4M per year. The U.S. Geological Survey performs Antarctic mapping, geology, geophysics, glaciology, and long-term ecological monitoring at about $2M per year. The Department of Energy and the Smithsonian Center for Astrophysics fund astrophysics in the Antarctic at $140,000 and $115,000 per year.

Other agencies dealing with Antarctic matters include the U.S. Coast Guard, the Marine Mammal Commission, the Department of State (international representation, the U.S. role under the Antarctic Treaty, and chairing the interagency policy mechanism), the Environmental Protection Agency (environmental advice and oversight), and the Council on Environmental Quality (environmental protection policy).

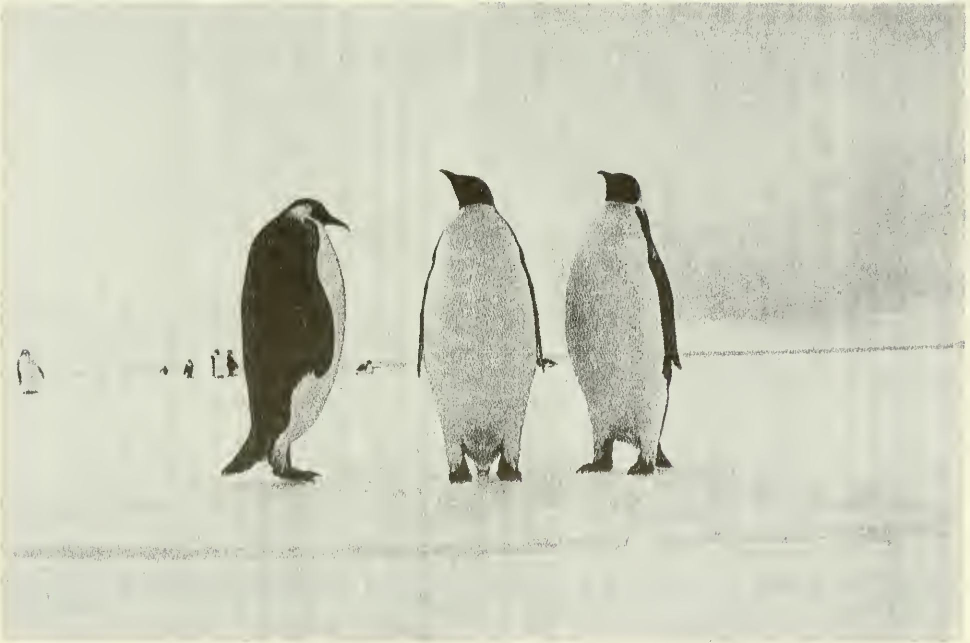
With NSF funding, the Department of the Interior provides leasing services for non-DoD aircraft; the Naval Electronics Command, satellite communications expertise; the Department of Transportation, icebreaker operations; and the Department of Defense, as discussed elsewhere in this report, the backbone of Antarctic air and sea logistics. DoD, with close NSF involvement, currently is shifting Antarctic LC-130 operations from the Navy to the New York Air National Guard as the Navy implements its planned withdrawal from the U.S. Antarctic Program.

E. NSF Contributions to Arctic Research

NSF also supports significant scientific research in the Arctic. There are often relationships between research activities supported in the Arctic and the Antarctic (for example, in glaciological and auroral studies). However, there are important differences in NSF's mandates for the two polar regions.

With respect to the Arctic, NSF is one of a number of Federal agencies with responsibilities for arctic research and logistics. Since the U.S. has territory in the Arctic, support of Arctic research is similar to that carried out in other parts of the country, with Federal agencies performing or supporting research relevant to their missions. Twelve Federal agencies supported arctic research and associated activities in FY 95 at a combined level of $175M; NASA and NSF are the largest funders at more than $40M each. These figures do not include Arctic research supported by the State of Alaska and the private sector. NSF, in addition to its general role of supporting fundamental research and education in science and engineering, has responsibilities for promoting interagency coordination of arctic research, including chairing the Interagency Arctic Research Policy Committee under the Arctic Research and Policy Act.

In carry out this mandate NSF benefits from the advice of the interagency Antarctic Policy Group, National Academy of Sciences/National Research Council, Polar Research Board, and the National Science Board (see Appendix V). With respect to Antarctica, NSF's mandate is to budget for and manage the entire U.S. national program, including operational support, so that the Program can be managed as a single package. The Program, therefore, is designed to support the full range of U.S. national interests in Antarctica.



One of the 17 types of penguins, the Emperor penguin breeds on the sea ice surrounding Antarctica during the dark, frigid austral winter. Using satellites during the winter to observe these sea birds, U.S. biologists are beginning learn more about the emperors and how they interact with their environment.

Emperors of the Antarctic

Of the 17 species of penguins, only emperor penguins breed during the extreme Antarctic winter, when temperatures can drop to below -50°C and winds can reach 300 kilometers per hour. The total number of emperor penguins is unknown because new colonies are still being discovered, but population estimates range from 135,000 to 175,000 breeding pairs, living at about 40 sites on the sea-ice margin of Antarctica. Seven of these colonies are in the Ross Sea, where U.S. scientists have been studying them since the early 1960s.

The breeding cycle of emperor penguins begins in early April, when the adults return to their traditional nesting sites. After laying one egg, the female leaves the colony, traveling as much as several hundred kilometers to feed at sea. The male emperor incubates the egg throughout the dark winter, keeping it balanced on his feet and protected under a pouch of skin. The males huddle in large groups for warmth, fasting the entire time. By the time a chick hatches, the male may have lost up to half his body weight. The female returns in mid-July with the chick's first meal, allowing the male to travel for food and beginning a cycle in which the adults alternately feed and guard the chicks. Because the emperor penguin chicks hatch in early spring, they will have the entire summer to be fed and to grow to maturity before the next winter sets in. Even so, only 20% of the chicks will survive their first year in the harsh Antarctic environment.

Innovative techniques have been used to study these amazing birds, the largest of the penguin species. Tiny satellite transmitters, glued to the birds' feathers, enable scientists to track their movements to ice-free feeding areas during the summer. Although scientists assumed that the birds would feed near their colony, satellite data surprisingly showed that the birds routinely traveled hundreds of kilometers during 2- to 3-week feeding trips.

Depth recorders have shown that emperors dive deeper than any other known bird. They can dive to depths of up to 630 meters, where the pressure would crush human lungs. No one knows exactly how the birds survive or how they find their food in complete darkness.

There are many other unknowns about the emperor penguins, including how they develop so rapidly the ability to dive to great depths. Research has shown that the oxygen storage capacity of an adult emperor's muscle tissue is about 12 times that of a chick's. Yet, the chicks do not enter the sea until summer's end, when they head out into the ocean on their own. Apparently, they develop the unique metabolism of a deep-diving aquatic animal almost overnight, a process not at all understood by scientists. Continued research should bring some answers to these and other puzzling questions about the most majestic of Antarctica's residents.

Chapter II
United States Antarctic Policy

A. United States Interests

The United States has important interests in Antarctica. We have long been a leader in scientific research there, research that provides insights essential to the understanding of the planet. The major U.S. commitment to Antarctic exploration and research over the past four decades has been based upon the unique opportunities offered by the continent and surrounding waters to carry out basic research in astronomy and astrophysics, glaciology, geology, geophysics, oceanography, the atmospheric sciences, ecology, biology, and biomedical science.

U.S. scientific interests have been matched by important political, security, economic and environmental interests, including maintenance of the viability of the Antarctic Treaty and associated agreements that are the indispensable framework through which we have pursued and achieved our interests.

U.S. Antarctic policy, therefore, as set forth most recently in Presidential Decision Directive NSC 26 of June 9, 1994, has four basic objectives:

(1) protecting the relatively unspoiled environment of Antarctica and its associated ecosystems;
(2) preserving and pursuing unique opportunities for scientific research to understand Antarctica and global physical and environmental systems;
(3) maintaining Antarctica as an area of international cooperation reserved exclusively for peaceful purposes; and
(4) assuring the conservation and sustainable management of the living resources in the oceans surrounding Antarctica.

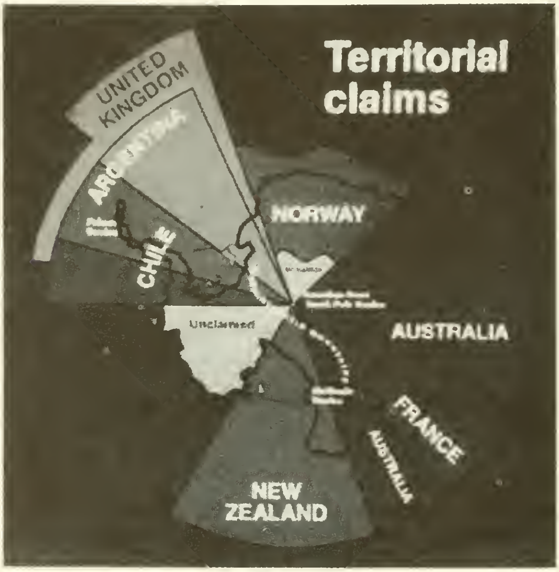
These interrelated interests are the rationale for the establishment and continued investment in a focused and organized national program of research in Antarctica.

B. The Antarctic Treaty

The ability to achieve United States' objectives, particularly in light of differences among nations over claims to territorial sovereignty in Antarctica depends upon a unique framework of international agreements. This framework is provided by the Antarctic Treaty of 1959, as well as measures adopted pursuant to the Treaty and related legal agreements resulting from initiatives under the Treaty. Collectively, these are known as the Antarctic Treaty system. (See Appendix I.)

The basic feature of the political geography of Antarctica is the dispute over territorial sovereignty there. Seven nations — Argentina, Australia, Chile, France, New Zealand, Norway and the United Kingdom — claim territorial sovereignty over parts of Antarctica. The claims of Argentina, Chile, and the United Kingdom overlap in the Antarctic Peninsula. In addition, a part of the continent is unclaimed. The United States neither asserts a claim nor recognizes the claims of others. At the same time, the United States has maintained a basis of claim, deriving originally from early U.S. expeditions of exploration and discovery in Antarctica.

**Figure II-1. Antarctic territorial claims by seven nations.
Most ATCP nations, including the United States, do not recognize these claims.**



The Antarctic Treaty "freezes" the positions of both claimants and non-claimants and thereby permits its Parties to undertake cooperative activities and agree on collective regulation of those activities, without prejudice to their legal positions. This conflict avoidance and conflict resolution mechanism is key to the political system of governance embodied in the Treaty. The primary provisions of the Treaty are:

- the guarantee of freedom of scientific research in Antarctica;
- reservation of Antarctica exclusively for peaceful purposes, including a prohibition on all military activities;
- balance between the opposed legal positions on the status of Antarctica (claimant vs. non-claimant);
- consensus as the basic principle of decision-making; and

- conduct of substantial scientific research in Antarctica as the basis for full participation in decision-making (the "activities criterion").

Maintaining the system of governance which has evolved under the Antarctic Treaty, and ensuring that is continues to be a dynamic and responsive mechanism, thus, is also a key element in achievement of U.S. Antarctic policy objectives.

C. United States Presence

The permanent presence in Antarctica resulting from the research activities supported by the U.S. Antarctic Program also has major political and security benefits for the United States. (See Department of State Memorandum to the National Security Council at Appendix II.) The influence of a Party to the Antarctic Treaty is directly linked to the extent and quality of its scientific presence in Antarctica. The United States Antarctic Program accords us the leadership role in Antarctica.

For these reasons, U.S. Antarctic policy for 25 years has affirmed the importance of an "active and influential U.S. presence in Antarctica." This has been defined to include the conduct of scientific research in major disciplines and year-round occupation of three research stations, including the South Pole.

The need for an active and influential U.S. presence in Antarctica to achieve our national interests and policy objectives has remained constant through major changes in the political and economic forces affecting Antarctica. It has underpinned U.S. leadership in Antarctic affairs as the number of nations active on the continent continues to grow (from 12 in 1961 to 26 in 1996). It is the basis for our role in the successful management of fishing activities in Antarctic waters, where, U.S. commercial fishing interests are growing.

Moreover, the importance of an active and influential presence has not waned with the end of the Cold War. While there was an element of rivalry between the United States and the Soviet Union in Antarctic activities, there was also an identity of interests with common commitment to maintaining Antarctica as a zone of peace and with common positions on the legal and political status of Antarctica as non-claimant nations. Russia remains a player, but with diminished influence. This has increased the importance of U.S. leadership in maintaining the political and legal balance that makes the Antarctic Treaty a uniquely successful international mechanism.

For these reasons, the NSTC believes that at the current level of investment, a strong, year-round U.S. presence in Antarctica, including the three research stations, is necessary to serve basic U.S. science interests, as well as U.S. interests in maintaining the international peace and stability and an effective system of governance established by the Antarctic Treaty.

Amundsen-Scott South Pole Station is of particular scientific and strategic importance. It is located on the summit of the polar ice cap and at the point of intersection of territorial claims that the United States does not accept.

As is pointed out in the Department of State Memorandum (Appendix II):

> .. *United States presence at the South Pole Station demonstrates United States commitment to assert its rights in Antarctica, its basis of claim and its commitment to cutting edge scientific research there. Abandonment of the Station would create a vacuum and likely result in a scramble to occupy the site to the detriment of our position as well as to the stability of the Treaty system.*

In sum, the NSTC concurs with the conclusion of the Department of State Memorandum that "it is essential that the United States continue to maintain an active and influential presence in Antarctica, including year-round operation of South Pole Station." The NSTC also endorses a continuing search for options that increase the cost effectiveness of maintaining this "presence."

Chapter III
Antarctica: A Unique Laboratory for Science

A. United States Investments in Scientific Research in Antarctica

Science is the principal human activity in Antarctica. The continent and the seas around it are a natural laboratory in which to investigate fundamental questions in astronomy and astrophysics, glaciology, geology, geophysics, oceanography, the atmospheric sciences, ecology, biology, and biomedical science. Insights from these disciplines provide new knowledge, with global implications. The harsh, desolate, and remote land areas provide unparalleled research analogs for other planets.

Since the International Geophysical Year (IGY) of 1957–1958, the U.S. has been the leader in scientific research in Antarctica. U.S. investment in Antarctic exploration and research over the past four decades is consistent with the region's scientific opportunities. The return for the nation's investment has been (i) a broad spectrum of results of meritorious scientific research, described below; (ii) a capacity to work at the cutting edge of science under harsh and remote conditions; and (iii) an operational infrastructure, essential to continuation of this science, that is unequaled by any other nation.

The NSF assures excellence by funding the best proposals received from scientists affiliated with universities and other research institutions (see Appendix III for a list of institutions funded in FY 95). USAP conducts competitive reviews of proposals to establish scientific quality, and the scientifically meritorious proposals receive logistical, environmental, and safety reviews.

Research and education in the USAP are driven by the desire to understand fundamental phenomena and processes and to use that understanding to serve society. The science may be viewed as having three overlapping perspectives afforded by the special conditions that exist in Antarctica. These three perspectives are described below.

1. Understanding the Earth and Its Large-Scale Systems

Antarctica and its surrounding oceans — 10% of Earth's land mass and 6% of its oceans — provide major opportunities for research to expand fundamental knowledge of the region and to help us understand global issues such as continental drift, climate change, ocean circulation, and pollution. Antarctica holds a key to understanding continental drift and plate tectonics because it has been a major component of several supercontinents. Changes in the region's oceans pivotally influence world deep ocean circulation and biotic productivity. Isolation from industrial centers has made the region ideal for measuring natural variability of the atmosphere and anthropogenic impacts on it. The continental ice sheet volume and the seasonal variation in sea ice extent beyond the continent influence atmospheric and oceanic circulation around Antarctica. Human-caused increases of greenhouse gases (e.g., CO_2, chlorofluorocarbons, and methane) may have profound effects in the region, where models predict greater change than in temperate latitudes. The southern ocean is a major sink for atmospheric gases, particularly CO_2; the estimated absorption is about 30% of the CO_2 discharged worldwide into the atmosphere.

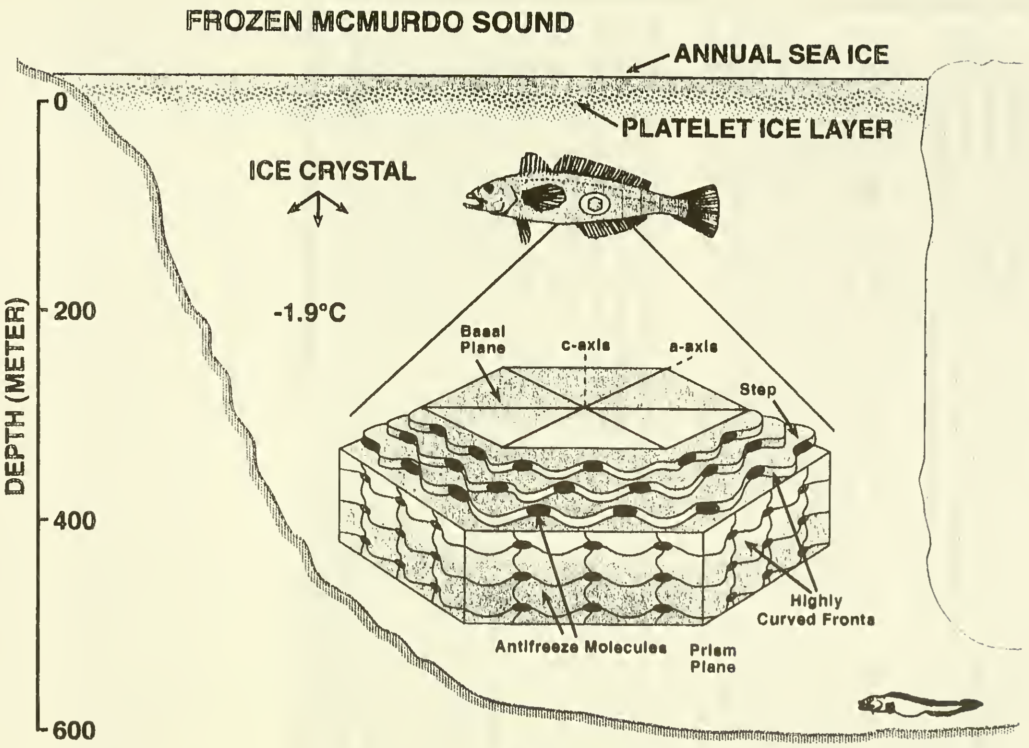
This latter topic will receive attention in the next few years under the southern ocean Experiment of the international Joint Global Flux Study (JGOFS). This study traces the oceanic branch of the flow of carbon from fossil-fuel burning on land through the atmospheric carbon dioxide reservoir into the ocean to ultimate burial in the sea floor. In the ocean, carbon dioxide takes many interconnected pathways through the food chain, few of which are well known. These pathways depend on the levels of dissolved nutrients, the activity of bacteria, the amount of available sunlight, and the levels of trace metals such as iron. It is not yet known how these processes work together in the southern ocean and how they will respond to and affect global change.

Upon completion of JGOFS, the Global Ocean Ecosystems Dynamics (GLOBEC) will extend to the southern ocean. Organized by oceanographers and fisheries scientists, GLOBEC asks how environmental change affects the abundance and production of marine animals. The southern ocean contains huge quantities of zooplankton (which feed fish and animals at higher levels in the food web), and it drives global ocean circulation. Because of these features, the southern ocean work can combine the goals of JGOFS and GLOBEC: investigators will be able to assess the effects of climate change on the cycling of chemical constituents through both the marine food web and the inorganic environment, and they will study how these processes interact to control the productivity of marine life. Before field work begins, modeling studies will be supported to guide the design and implementation of the projects.

Recent research on the virtual elimination of stratospheric ozone over Antarctica each spring has aroused international attention. Data collected in Antarctica show that atmospheric chemistry processes, stimulated especially by the buildup of artificial chlorofluorocarbons (CFCs), is destroying the ozone. One consequence of a decrease in ozone is an increase in the amount of ultraviolet radiation reaching Earth, which if sustained could cause skin cancer, cataracts, and immune system damage to higher animals, including humans. Research on Antarctic phytoplankton has shown that their concentration is measurably decreased by increased ultraviolet radiation.

Following are additional examples of research on the involvement of the Antarctic in global processes.

- Research on the Antarctic ozone hole by many researchers supported by the USAP and other agencies, among them Susan Solomon (NOAA Environmental Research Laboratories) led to award of the 1995 Nobel Prize in Chemistry to Paul Crutzen, Max-Planck-Institute for Chemistry, Mainz, Germany, Mario Molina, MIT, and F. Sherwood Rowland, University of California, Irvine, CA, for their pioneering work in atmospheric chemistry, particularly concerning the formation and decomposition of ozone.



The antifreeze molecules allow icefish to live in subfreezing water by plugging gaps in existing small ice crystals and preventing the attachment of more ice molecules. Ice crystal growth is thus effectively stopped.

Fish Antifreeze Proteins

To survive, Antarctic fishes have developed proteins that act as antifreeze. These antifreeze proteins are a group of unique macromolecules that help some polar and subpolar marine bony fishes avoid freezing in their icy habitats. The proteins were discovered by Dr. Art DeVries from fish that he collected at McMurdo Station while he was a graduate student at Stanford University in the early 1960s.

Waters of the southern ocean are so cold that temperate and tropical fish would freeze if they were placed in this environment. The presence of salt in sea water allows it to remain liquid until about -1.9°C, almost 2 degrees below the freezing temperature of freshwater. The antifreeze proteins, along with normal body salts, depress the freezing point of blood and body fluids to -2.5°C, slightly below the freezing point of sea water. These proteins bind to and inhibit growth of ice crystals within body fluids through an absorption-inhibition process. The proteins attach to small ice crystals, stemming their growth. This mechanism that inhibits further growth of the ice crystal remains under study, but apparently Antarctic fish are able to survive with very small ice crystals present in their body fluids.

There may be several commercial applications of these antifreeze proteins. These compounds are about 300 times more effective in preventing freezing than conventional chemical antifreezes at the same concentrations. The effectiveness of the fish antifreeze proteins in inhibiting ice growth suggests that they could be used to prevent freezing of food and freezing injury in several applications. For example, they could be used in the cryopreservation of foods that normally are rendered inedible due to ice crystal damage or to engineer cold resistance in living plants, as well as for the cryopreservation of tissues and organs. The study of the mechanism of how antifreezes bind to ice and inhibit its growth also provides insights into how other biomolecules affect growth of such pathogenic (harmful) bio-crystals as those associated with gout, kidney, and gall stones. Lastly, these proteins may have applications as non-polluting de-icing agents. To date, NSF-funded investigators have successfully introduced two of the four different types of fish antifreeze proteins into yeast and bacteria through recombinant DNA technology. Using these cloned genes and molecular technology, researchers can produce large quantities of antifreeze proteins through large-scale fermentation.

- Located under the ozone hole, the three U.S. Antarctic stations monitor ozone-related changes in the stratosphere, resultant changes in ground-level UV radiation, and the response of organisms to these changes. Collaborative, interagency research has explained the fluorocarbon cause of the ozone hole, and future work will monitor the magnitude of the phenomenon.

- The annual expansion and contraction of sea ice doubles the area covered by ice in the southern hemisphere; it is one of the planet's major seasonal events. The sea ice, which reaches a maximum area of 8 million square miles, is a habitat for organisms from bacteria to marine mammals. Understanding the dynamics and thermodynamics of this system is critical for understanding the role of the Antarctic region in climate change and world ocean circulation. Results include a quantitative understanding of bottom water production in the Weddell Sea, more accurate interpretation of satellite images of sea ice, and the integration of ice models, ocean models, and atmospheric models for more realistic simulations of climate processes.

- West Antarctica contains rifted, and therefore thinned, continental crust beneath the world's last marine-based ice sheet. Consequently, this region is the most important region in the world for understanding the possibilities of future sea level change. The discovery of ice streams within the west Antarctic Ice Sheet has led to an understanding of glacial flow and the potential for ice sheet collapse.

- Antarctica, especially East Antarctica, has been a central part of at least two supercontinents during the last 25% of Earth's history. Evidence of dispersal of life forms among these major continents is preserved here. This work has led a new hypothesis, now being debated, that Antarctica and North America were once adjacent. Resolution of the debate is crucial for organizing and understanding geologic data worldwide.

- The South Pole's distance from centers of human population and industry make it an ideal location to monitor the background composition of the planetary atmosphere. For example, on behalf of C.D. Keeling (Scripps Institution of Oceanography) and NOAA, the station has an unbroken 37-year data set of atmospheric CO_2.

2. Antarctica as a Unique Natural Laboratory

Antarctica is the coldest, driest, highest, windiest and most isolated continent on Earth, and as a result Antarctica is an expensive and difficult place to do research. However, these unique conditions also provide the opportunity to do research that can be only or best accomplished in the Antarctic. The region, spanning a wide range of latitudes, provides an ideal platform without international boundaries. Following are some examples of USAP results in several different research areas.

- Antarctica is the source of most of the world's meteorites. Meteorites offer clues to the origin of the solar system. Certain locations on the margins of the Antarctic ice sheet are known to contain many meteorites, concentrated by glacier movements. Planetary scientists regard these meteorites as a very valuable research resource. While most meteorites originate in the asteroid belt, a few of the Antarctic samples found by the USAP have been confirmed as being from Mars. Some of these meteorites reflect the presence of water on Mars, adding to speculation about the existence of life there.

- The single annual day-night cycle at the geographic South Pole allows continuous observations of the skies for long uninterrupted periods. The best early developments and results in solar seismology came from USAP-supported work at the South Pole and used the continuous availability of the sun to get high-quality data that constrained solar models fundamental to stellar evolution.

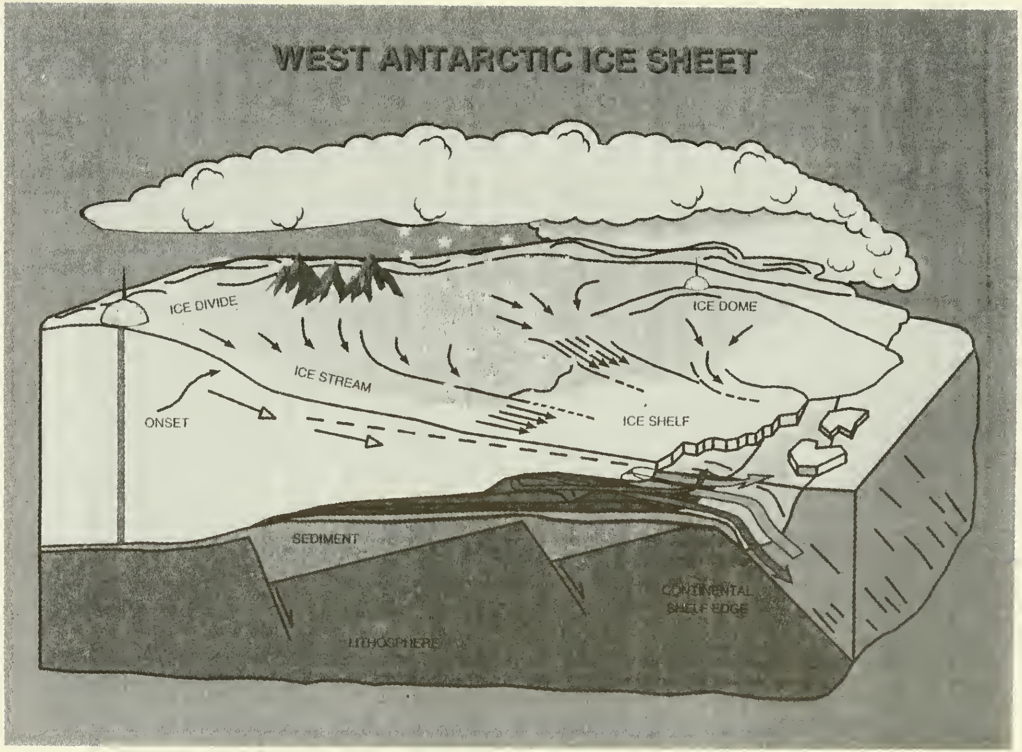
- The stratospheric polar vortex allows long-duration, high-altitude balloons to circumnavigate the continent while continuously observing cosmic and solar phenomenon. Previous flights have observed the details of x-ray production in solar flares, the most energetic explosions in the solar system. The process by which this energy is generated — magnetic reconnection — may occur in many different types of x-ray sources throughout the Galaxy.

- Because of the low temperatures and the near absence of water vapor in the atmosphere above the polar plateau, the infrared skies are consistently clearer and darker than anywhere else on Earth, making the geographic South Pole the world's best existing observatory site for infrared and submillimeter astronomy. Observations at very low frequencies in the electromagnetic spectrum have the potential for answering major questions about the formation of the universe, including the processes by which stars form from interstellar gas, the formation of planets, the nature of primeval galaxies, and the distribution of matter and energy in the early universe.

- The low background emission and lack of radio interference at South Pole (due to its remoteness) have permitted some of the best measurements of the cosmic background emissions from the Big Bang, which marked the beginning of the Universe. These measurements, at a smaller angular scale, complement those made from space by, for example, the NASA COBE mission.

- The polar plateau is an extensive, deep and dark, but remarkably transparent ice sheet that appears to be ideal to support the installation of a muon and neutrino detector array for mapping extraterrestrial neutrino sources. This recently recognized feature of the ice sheet will open new opportunities in neutrino astrophysics, offering insight into the high energy physics of the most explosive phenomena in the Universe.

- The more than 8-month isolation at South Pole Station (and a somewhat shorter isolation at McMurdo) creates the longest planned isolations of large groups in a confined environment. Studies of physiological and behavioral response in these groups have produced knowledge that may be useful for planning long-term space voyages.



Block diagram showing a schematic cross-section of the West Antarctic ice sheet, which is drained by ice streams underlain by water-saturated, unconsolidated sediment. The underlying lithosphere (bedrock) may play role in the presence of the ice streams.

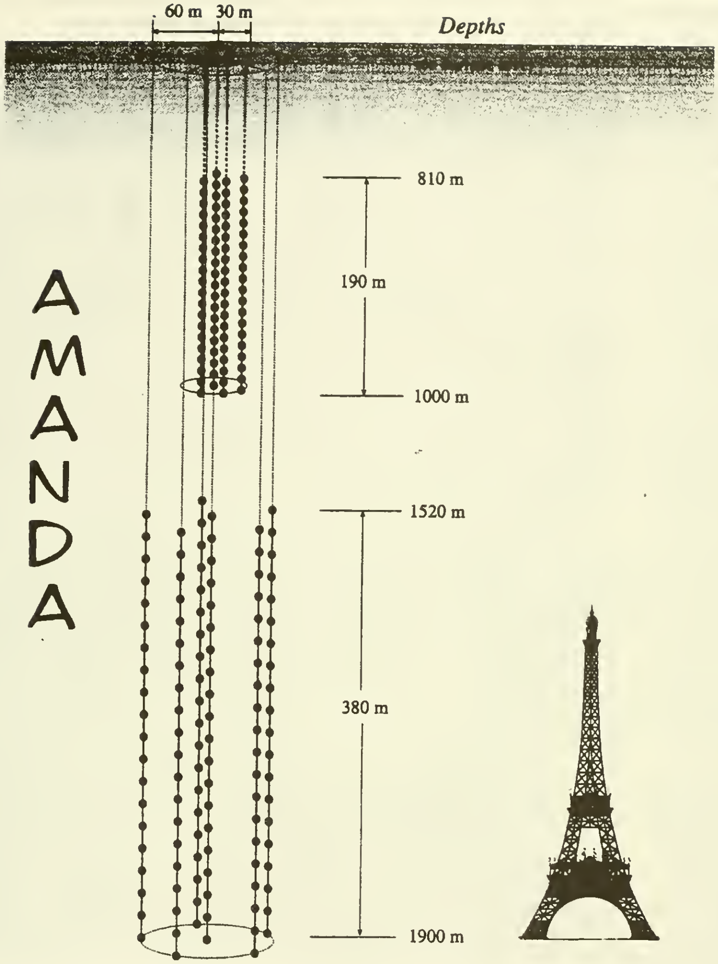
West Antarctic Ice Sheet Stability and Global Sea Level

The west Antarctic ice sheet is the world's only remaining marine ice sheet, an ice sheet anchored to bedrock below sea level and with margins that are floating. Other marine ice sheets existed in the Northern Hemisphere during the last glacial maximum but all disintegrated and melted away during the current warm period. Marine ice sheets are important because their existence and future behavior depend not only on atmospheric conditions and ice movement, but also on sea level changes. As the sea level rises, more of the ice at the edge of the sheet floats, and the forces that hold the ice sheet together are reduced, causing ice to flow more rapidly to the oceans. This positive feed-back loop (sea-level rise, leading to reduced forces holding the ice together, leading to increased ice flow into the ocean, leading to sea-level rise) could lead to rapid disintegration or collapse of a marine ice sheet. Scientists want to learn more about the west Antarctic marine ice sheet to understand how it operates and to determine if it is vulnerable to future disintegration or collapse, which would affect global sea level.

Scientists have long recognized that global sea levels were 5 to 6 meters higher during the last interglacial warm period, about 125,000 years ago, than they are today. It is also estimated that the west Antarctic ice sheet contains ice which, if it were incorporated into the oceans, would cause global sea levels to rise about 6 meters. It has been suggested that the West Antarctic ice sheet might be responsible for the higher sea level during the last interglacial period. Future global warming could result in the disappearance of the West Antarctic ice sheet and a substantial rise in global sea level.

The west Antarctic ice sheet is drained by surprisingly large, fast, river-like currents of ice flowing through the ice sheet. These ice streams, as they are called, are up to 100 kilometers wide and several hundred kilometers in length, moving at rates as fast as several hundred meters per year. Studies have shown that the ice streams are underlain by a water-saturated, unconsolidated sediment layer a few meters thick. This sediment acts to lubricate the ice streams so that they flow rapidly over their beds. The size and speed of the streams lead to the possibility of rapid collapse of the ice sheet.

The West Antarctic Ice Sheet Program is an interdisciplinary program to study this ice sheet, understand the processes important to its behavior, and develop models to predict its future behavior. Recent studies suggest a possible connection between the subglacial geology and the presence of the ice streams. In fact, measurements of ice thickness, magnetics, and gravity, made using a specially equipped aircraft, have shown that there is evidence for high heat flow and active volcanism near the ice streams. These elements could explain the high degree of subglacial melting and lubrication of the sediment under the ice streams. This work demonstrates the importance of subglacial geology for a complete understanding of the stability of the west Antarctic ice sheet, its ice streams, and its potential for raising global sea levels.



AMANDA, when completed, will reach a depth equal to more than two and one-half times the height of the Eiffel Tower. Into each of the eight holes melted into the glacial ice are lowered strings, each studded with 20 modules that can detect and record neutrinos as they pass through the ice.

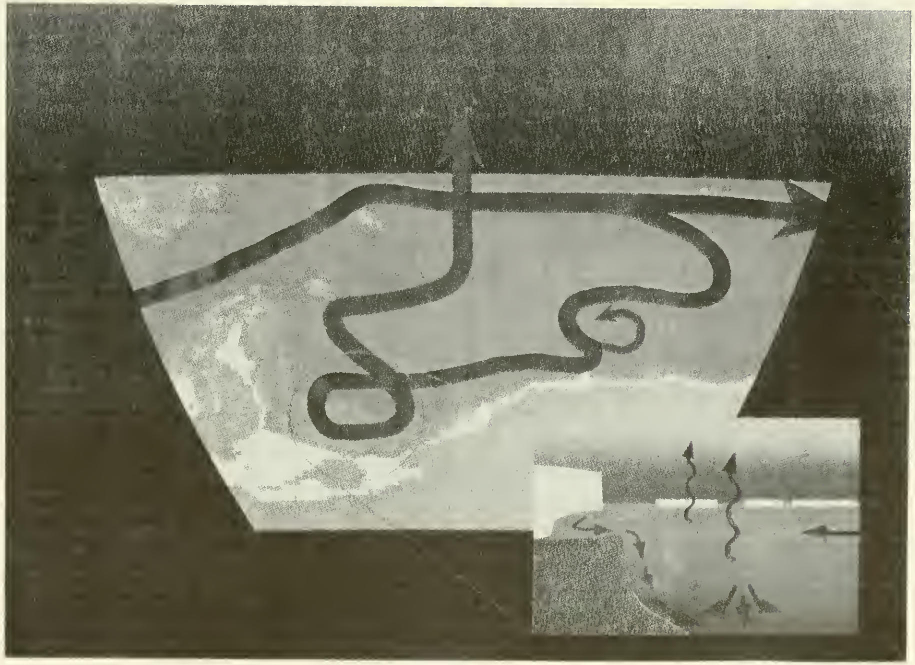
AMANDA: The Antarctic Muon and Neutrino Detector Array

Whenever scientists have looked at nature through "new eyes," using probes previously unavailable, unanticipated discoveries have resulted. Examples include Galileo's use of the telescope to discover Jupiter's moons and Saturn's rings; the use of x-rays to see inside of living tissue; and the different universe that is seen in the infrared, x-ray and gamma-ray portions of the electromagnetic spectrum. In the past decade or two technology has made it feasible to build a "telescope" that can image the sky in high-energy neutrinos.

Neutrinos, one of the most common subatomic particles in nature, interact only weakly with ordinary atoms, making detection difficult. Even though an enormous flux of neutrinos continuously bombard Earth, almost all pass completely through without interaction. Because neutrinos are so penetrating, they allow astronomers to see inside such celestial objects as the cores of galaxies, enshrouded with dust and gasses that obstruct observations made with any wavelength of electromagnetic radiation. However, detecting a neutrino takes an enormous detector with a very good filter. The solution to this problem is to use cheap material for the detector, with a large shield to keep out unwanted radiation and particles. So far the only candidates for the detector material are water or ice. The shield is provided by looking for only upward-going neutrinos that must have passed through Earth, something no other known particle can do. The detector also should be buried deeply to limit interference from downward-going muon particles that cosmic rays produce in the atmosphere. Detectors currently under construction are DUMAND in the Pacific, NESTOR in the Mediterranean, BAIKAL in Lake Baikal, Russia, and AMANDA at the South Pole.

Ice has advantages and disadvantages compared to water. On the plus side, there is no radioactivity or bioluminescence, and the photodetectors operate at low temperature, which all reduce background. Also, ice forms a solid working surface above the detector, eliminating the need to run signals for tens of kilometers to shore and greatly simplifying the electronics. On the minus side, because the photodetectors are permanently frozen into the ice sheet, bad modules must be replaced rather than fixed. Additionally, because the ice sheet is not as thick at South Pole (2.8 km) as the depth of the ocean in many places, it is not possible to get as much shielding from cosmic-ray-produced muons as at DUMAND. One mixed blessing of working at the South Pole is that the entire northern sky can be watched all the time, but the southern sky is never in the field of view.

So far the AMANDA collaboration (University of Wisconsin, Universities of California Berkeley and Irvine, Universities of Stockholm and Upsalla in Sweden, and DESY in Germany) has installed at South Pole eight long strings with 166 optical modules, at depths ranging from 800 to 2,200 meters. The ice is much clearer than anticipated from laboratory measurements; however, at the shallower depths (less than 1,500 meters) air bubbles remain and cause excessive scattering, making that part of the ice sheet less useful. Consequently, future development is expected to be done in deep ice. Although the detector is only about one quarter finished, the AMANDA collaboration has already begun looking for neutrinos. AMANDA also is being used to detect supernova and gamma-ray bursts. Surprisingly, the major results to date concern the optical properties of the bulk ice. Not only is the ice is much clearer than any laboratory measurement of "pure" water ice, but it also appears to be to be clearer than many other "clear" solids such as salt. The AMANDA results have initiated a rethinking of the optical nature of solids and may well produce fundamental contributions to condensed matter science.



B. Huber/A. Gordon LDEO

Warm circumpolar water passes through the Drake Passage and flows eastward in the Antarctic Circumpolar Current (red arrow). Some of the flow is diverted southward into the Weddell Gyre and becomes more dense, sinks, and flows out near the bottom (blue arrow). The inset illustrates the two processes that increase the density: lowering the temperature by giving up heat to the atmosphere, and raising the salinity of the remaining sea water by forming nearly salt-free ice in the very cold environment.

Antarctica's Important Role in Global Ocean Circulation

Predicting near-term global climate changes depends on how well the many processes that make up Earth's climate system are understood, how realistically these can be expressed in global change models, and how effectively the evolution of the system can be extracted with powerful supercomputers.

One of the most important processes—one that is uniquely related to the Antarctic—is ocean ventilation, the process by which the deep ocean affects the atmosphere on the time scale of decades to centuries.

If we could mark a cubic meter of sea water and follow its global meanderings through the various oceanic current systems, we would find that it spends most of its time isolated in the deep ocean, where it is dark and cold. Only occasionally—once every 600 years on the average—would it appear on the surface, and then only in high southern latitudes. In the tropics and sub-tropics, a thin surface layer of warm (hence lighter) water prevents deep water from coming to the surface. South of the Antarctic Circumpolar Current, this warm layer disappears and no longer inhibits the upward movement of water. This process is called overturning or ventilation of the ocean. Typically, when deep water reaches the surface, it gives up heat to the much colder atmosphere and picks up dissolved atmospheric gases, including carbon dioxide.

The ventilation or overturning of the ocean can affect climate change in two important ways. The delivery of heat to the atmosphere raises the temperature at high southern latitudes, and the removal of carbon dioxide into the deep ocean for long-term storage reduces the greenhouse effect. The removal of carbon dioxide is crucial for global change.

We have learned much about how carbon dioxide and water vapor—two greenhouse gases—act as an insulating blanket in the atmosphere and that the surface temperature will increase as the atmospheric level of carbon dioxide increases. For nearly 40 years the rise of carbon-dioxide levels in response to fossil fuel and biomass burning, as well as fluctuations due to natural effects, has been observed.

However, to express effectively how the atmosphere reacts to the production of greenhouse gases in a global climate model, we have to understand how the atmosphere can shut off the overturning of the southern ocean. We can think of at least two ways: one is to create less dense water at the surface through warming or increased precipitation at high latitudes; the other is to slow down the Antarctic Circumpolar Current. The study of these processes is a continuing high priority in Antarctic oceanography.

3. Exploration of the Geographical Frontier

U.S. exploration in Antarctica began in the 1790s with American sealers exploring islands around the Antarctic Peninsula. The U.S. did not participate in the Heroic Era of Antarctic exploration in the early 1900s, but resumed involvement in 1928 with Richard E. Byrd's expedition. Byrd acquired more geographical, geological, and meteorological information about the Antarctic than any other expedition of the time. During the 1930s, Byrd continued exploration and mapping — including aerial surveys — and work in several scientific fields.

In the footsteps of the early explorers, U.S. investigators continue to explore the Antarctic using advanced technology. Contemporary exploratory research goes beyond mapping to address questions across many scientific disciplines. Here are some examples:

- ***Aerogeophysical Research:*** Using McMurdo Station as a staging area, an airplane with laser altimeter, ice-penetrating radar, aerogravity and aeromagnetic systems, and precision GPS images the surface and the bed of an ice sheet while measuring the gravity and magnetic signature of the lithosphere below. With these data researchers have a start on selecting a site for deep ice coring during the West Antarctic Ice Sheet (WAIS) program.

  In addition to understanding the role of the Antarctic ice sheets in climate models, the ability to predict future behavior of the west Antarctic ice sheet is key to prediction of global environmental change. Next field season, investigators expect to finish surveying the first corridor across the central part of West Antarctica and to begin acquiring more data on fast-flowing ice streams. Aerogeophysics already conducted has led to discovery of a subglacial volcano near the source of a major ice stream. This buttresses one theory of ice stream flow, namely a thermal source for a fluid-rich slurry between ice and underlying continental crust.

- ***Swath Bathymetry of the Southern Oceans:*** Precision bathymetric maps — images of the ocean floor — are a fundamental tool for studying ocean basins. This information is for the ocean floor what topographic maps are for land. Bathymetric maps are essential to a range of disciplines including oceanography and earth sciences. For example, they provide boundary conditions for understanding ocean current flow. In earth sciences, bathymetric maps are the key to understanding sediment erosion and deposition processes in the ocean, processes related to glacial erosion and deposition on continental shelves, and plate tectonic processes that have shaped continental margins and ocean basins.

  The traditional means of constructing bathymetric maps is by compiling depth soundings along ship tracks. Even in regions with high ship traffic and thus much data, this method is difficult and inexact. In the southern ocean, where ship tracks are rare, most existing bathymetric maps approximate the ocean bottom crudely. Advances in sonar, a technique that uses sound to detect objects in water, have led to *multibeam swath bathymetry* or *swath mapping* systems. These systems use sound beams to detect the bottom of the ocean along a wide swath beneath a moving ship.

The U.S. Antarctic Program has equipped R/V *Nathaniel B. Palmer* with a modern system that uses 120 sound beams to image the bottom from directly below the ship out to an angle of 60° to each side. The resultant swath is more than three times wider than the water depth. In the ocean basins around Antarctica the width is 7 to 8 kilometers on each side of the ship's path, while on the continental shelves the width is about 1 kilometer on either side. This system images the ocean floor in an unprecedented way.

The images enable scientists to interpret the processes that shape the ocean bottom. For example, the shapes of deposits left by glaciers or the gouged and scarred troughs left by glaciers sliding over the bottom give clues to past ice sheet behavior and allow scientists to determine precisely where to take samples to determine the age of the features. Other shapes characteristic of volcanic and tectonic processes provide information about how the lithosphere formed beneath the ocean and what processes are active today.

One of the first uses of swath bathymetry on the R/V *Palmer* was to examine the sea floor by the Antarctic Peninsula for signs of active volcanism. While conventional bathymetry from previous work had shown the presence of large-scale volcanic features, the work on the R/V *Palmer* verified the gross volcanic features and showed smaller scale features in detail. Textures on the maps indicated mounds and other volcanic features on the sea floor that are characteristic of active hot springs. Such springs, known only at a few localities in the world, are the subject of intense study to understand the unusual life forms and the nature of heat and chemical exchange between Earth's interior and the oceans.

Future research will focus on past glacial activity on the continental shelves as well as on the tectonic processes that formed the ocean basins surrounding Antarctica. This research is important to resolving regional geologic questions and contributes to a general understanding of geologic processes that shape Earth.

- ***Radar Remote Sensing From Space.*** In an example of interagency and international cooperation, NASA launched a synthetic aperture radar satellite funded by the Canadian government, which wants to map the northern hemisphere including the Arctic. Next year, the satellite, called RADARSAT, will be maneuvered to view Antarctica, providing high-resolution maps impossible to achieve any other way. NSF and NASA have placed a receiving station at McMurdo that will be used in conjunction with similar facilities established in Antarctica by Japan and Germany. The three ground stations will permit RADARSAT coverage of the entire continent and some coverage by European and Japanese spacecraft. The data will help solve one of glaciology's grand unsolved problems — the mass balance of the Antarctic ice sheets, 70% of the world's freshwater. The sheets' growth and decay bear on future sea level; the knowledge will be used in global change models. The data also will enable mapping seasonal extent and characteristics of Antarctic sea ice, an important component of Earth's climate thermostat. And the McMurdo facility will provide coverage in an otherwise vacant region of sky for polar satellites. These data and others are sent to and analyzed at the Alaska synthetic aperture radar facility.

Effect of the Ozone Hole on Oceanic Life

As ozone is the only atmospheric gas that appreciably absorbs ultraviolet (UV) radiation, it is critical in protecting living organisms from excessive exposure. UV photons are sufficiently energetic that they damage DNA, the genetic material present in all living cells. The radiation can cause skin cancers and immune system damage in humans. Similarly, UV radiation is damaging to tissues and to the functions of plants and animals. While the most pronounced decrease in ozone concentration is associated with the Antarctic "ozone hole," ozone depletion has also been documented in the Arctic.

The NSF UV-Radiation Monitoring Network was initiated in 1988 to provide direct measurements of UV radiation reaching the earth's surface. The network instruments are now located at the three US Antarctic stations as well as in southern Argentina and Barrow, Alaska. Data from Antarctica clearly confirm an increase in UV radiation when the ozone hole develops.

The effect of UV radiation on the marine ecosystem is a major focus of research in Antarctica. Microscopic marine plants, or phytoplankton, form the base of the food web. Dependent on sunlight for photosynthesis, phytoplankton are restricted to the upper layers of the ocean where UV-B radiation penetrates with the sunlight. Even a small decrease in phytoplankton productivity due to UV exposure could have significant effects. A decrease could be relayed through the food web and affect larvae, fish, crabs, birds, and mammals, which could affect the global food supply.

Using real-time data from NASA satellites and the NSF network, research ships were able to follow the "footprint" of the ozone hole to conduct experiments of UV effects on marine plants and organisms. Measurements of phytoplankton growth under increased UV concentrations due to the ozone hole showed a decrease of 6 % to 12% compared to normal concentrations outside the ozone hole. Similar results were found in studies of phytoplankton growth near McMurdo Station. The ecological significance of this effect is currently being debated among scientists. Future studies will focus on other components of the marine ecosystems such as fish and invertebrate larvae living in the near-surface oceanic waters surrounding Antarctica.

Brenda Hall, graduate student at the University of Maine, is studying the glacial geology of the dry valley region near McMurdo Station.

Graduate Student Life in Antarctica

Working in Antarctica, one notices the youth of the population. A good example is Brenda Hall, a graduate student with Dr. George Denton at the University of Maine. Brenda was an undergraduate at Bates College, a small liberal arts college in Lewiston, Maine. She was the recipient of a Dave Research Apprenticeship and gained her first taste of polar research in the Canadian Arctic studying paleoclimates through lake sediments.

Brenda has now spent six austral summers in the McMurdo Dry Valleys of Antarctica, pursuing her Ph.D. Each season requires an intensive 6-months period of preparation and planning. Environmental assessments must be developed to address issues such as waste handling and the return of cargo. Transportation, food, supplies, and equipment have to be coordinated with various support organizations. She and two colleagues must be safe and self-sufficient for long periods when storms and bad weather prevent close support.

Field seasons consist of up to 100 days of tent life from November to February and require extremely hard labor, with virtually no recreation or privacy. Working days of up to 18 hours consist of mapping surface deposits and collecting samples for dating and sediment analysis. Daily life includes chores such as food preparation. No showers and minimal fresh clothing and personal effects make for a long season. Lack of contact with family, friends, and loved ones becomes especially poignant during the holiday season.

For her Ph.D. research, Brenda has been studying the last glaciation in Antarctica and its relationship to abrupt global climate changes and to the stability of the marine-based West Antarctica Ice Sheet. The primary part of the project is to map the extent of the Ross Sea Ice Sheet, a large grounded ice sheet that existed in the Ross Sea during the last global glaciation and was fed, in part, by the West Antarctic ice sheet.

Results are not yet final, but promise to provide exciting new information on Antarctic paleoclimate, lake-level variations, deglaciation of the Ross Sea, and the stability of the West Antarctic ice sheet; her work may address the fundamental problems of the cause of ice ages.

Working in Antarctica has been a tremendous experience for Brenda. Graduate students rarely receive opportunities to work on projects with such relevance to the "hot" topics in the field, particularly with outstanding logistical support. In addition, she enjoys the responsibility and challenges associated with managing a field camp and carrying out scientific research in such an isolated location. Such experience and responsibility at an early age lay the groundwork for future leadership and for a successful career. Every year more than 100 students do research in Antarctica or use Antarctic data in their research projects at their universities.

Additional examples of exploration of the Antarctic frontier:

- The southern ocean is the largest and most fertile of the world's oceans. Its cold, constant temperatures allow the distribution of marine organisms to span from the deep sea into shallow depths, thus providing a unique opportunity to study "deep sea" life in relatively shallow water. Recently, this productivity has been shown to be limited as much as 10% by UV radiation penetrating the upper regions. Separately, other research has documented both DNA damage caused by UV and the mitigating defenses adopted by marine organisms.

- The relatively few terrestrial and freshwater species in Antarctica result in simple ecosystems, which facilitates the study and interpretation of ecosystem dynamics. A recent discovery shows the Adélie and chinstrap penguin populations to be varying in consonance with a climate signal that may itself be due to the El Niño, showing the global organizing effect of this equatorial atmospheric periodicity.

- Because Antarctica contains almost 10% of Earth's continental crust, it has substantial geologic records of plate tectonic processes, evolution and dispersal of life, and evidence of past environmental conditions at Earth's surface. Studying the records provided by this crust is necessary for a balanced picture of Earth's geologic development. Using aerogeophysics to sense the crust underneath the west Antarctic has led to the discovery of volcanoes, which may themselves be melting the ice and lubricating its base to quicken its flow into the ocean.

- Antarctica has been in a near polar position for the last 100 million years, so the South Polar region contains records of climate and environmental change over a long period. The inference of a mild climate, indicated by beech tree fossils close to the South Pole as recently as two million years ago, cannot be reconciled with currently understood polar processes.

- In some consistently cold and dry parts of Antarctica, such as the McMurdo Dry Valleys, erosion is extremely limited. Surface weathering that could otherwise destroy fossils has not eradicated details of past life preserved in the rocks. Paleontological studies have revealed the existence of an Antarctic dinosaur (a large carnivore), a marsupial, and many other forms. Also, Antarctic fossil discoveries have helped clarify the record of destruction of many of the planet's species some 65 million years ago.

- The Dry Valleys also are ideal for the study of adaptation to extreme environments. The recent discovery of cyanobacteria some two meters deep in the ice covering Lake Bonney reveals the remarkable resiliency of life and provides a new approach to the relationships among solar input, lake thermodynamics, and dust.

B. U.S. Antarctic Stations

The year-round stations (see map on next page) were placed to meet research and operational needs, but their locations serve geopolitical purposes as well.

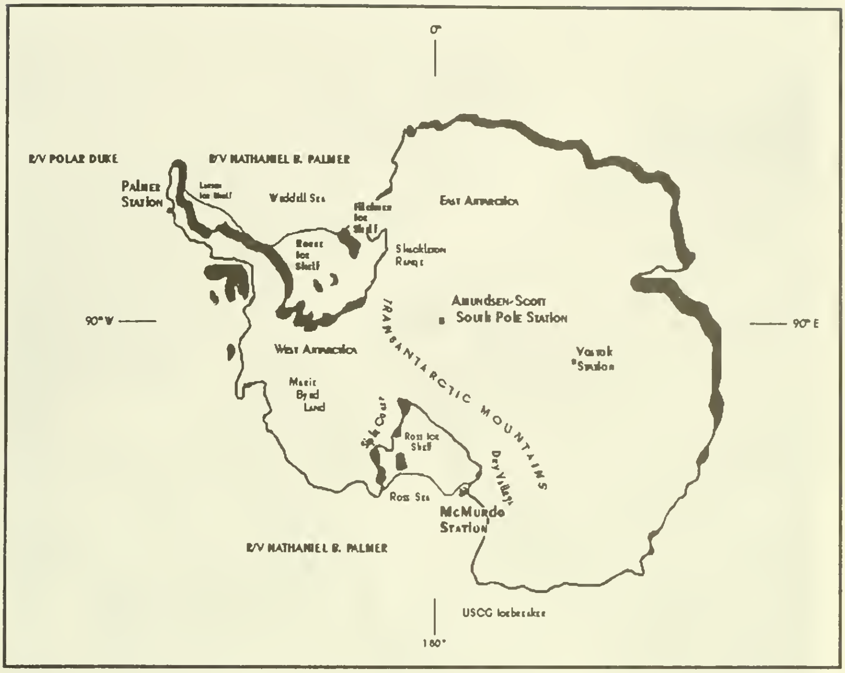


Figure III-1. Map of Antarctica showing major areas and facilities of interest to USAP

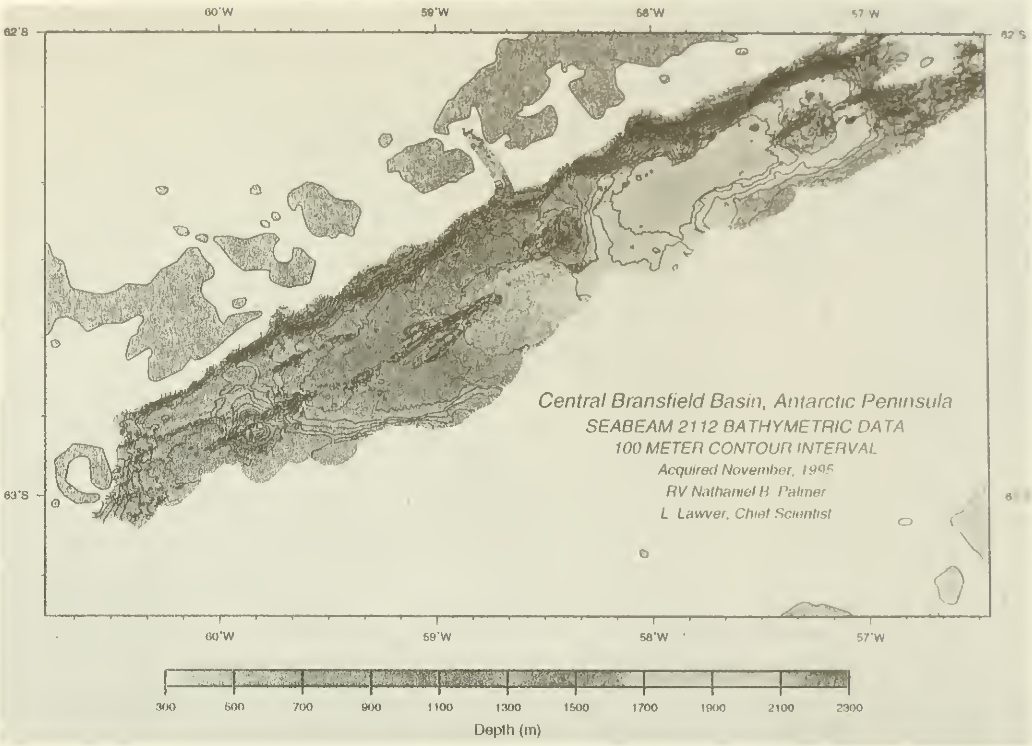
Research addressing interrelated Earth systems requires an array of research-support facilities. An example of coordinated use of U.S. Antarctic Program facilities is the West Antarctic Ice Sheet program, aimed at understanding the behavior of the world's only marine-based ice sheet left from the last ice age. This program includes aerial geophysics, oversnow geophysical and glaciological traverses, shallow and deep ice core drilling, marine geophysics and geology, and glacial geology. The aerial geophysics requires an inland camp supported through McMurdo. The glaciological and geophysical traverses depend on McMurdo's infrastructure and on temporary camps or seasonal facilities such as Byrd Surface Camp; South Pole Station also can be a hub for traverses. The snow coring and ice drilling require camps supported through McMurdo. All the camps and seasonal facilities, such as Byrd Surface Camp, depend on the heavy-lift, ski-equipped LC-130 airplanes, which in turn depend on air-support facilities at McMurdo. The marine research in the Ross Sea and coastal areas of west Antarctica requires R/V *Nathaniel B. Palmer*; this research would be conducted inefficiently without the ability to call at McMurdo for fuel, supplies, and scientist exchange. Without McMurdo, the ship would spend much more time in transit between the Antarctic and ports in southern hemisphere countries.

LAKE HOARE, SITE OF EXOBIOLOGY STUDIES,
ANTARCTICA DRY VALLEYS

Antarctica and NASA's "Origins" Program

Antarctica is an environment of extremes that has provided NASA with several avenues to explore our origins, from the formation of planets to the genesis and distribution of life. For example, although the arid, extremely cold ice-free regions of the continent appear barren, they actually harbor life in habitats analogous to those that could have supported life on ancient Mars. Because early Mars had liquid water, life could have begun there during the same time that life began on Earth. Antarctica offers Earth's best analog environment to ancient Martian environment, specifically before the planet lost most of its atmosphere.

In Antarctica, the Transantarctic Mountains block ice flowing from the east Antarctic plateau, forming the ice-free McMurdo Dry Valleys, a region with a mean annual temperature of -20°C. Although temperatures here seldom rise above freezing, microbial life has been found beneath perennially ice-covered lakes and inside porous sandstone rocks. In places never before suspected of harboring life, microorganisms are thriving wherever there is liquid water, even if only for a few hours a year. Research into these microbial habitats has expanded the known environmental limits for life on Earth and enhanced our understanding, which in turn will enable us to develop better strategies for the search for evidence of life on Mars, whether extinct or extant.


Central Bransfield Basin, Antarctic Peninsula
SEABEAM 2112 BATHYMETRIC DATA
100 METER CONTOUR INTERVAL
Acquired November, 1995
RV Nathaniel B. Palmer
L. Lawver, Chief Scientist
60°W
59°W
58°W
57°W
62°S
63°S
300
500
700
900
1100
1300
1500
1700
1900
2100
2300
Depth (m)

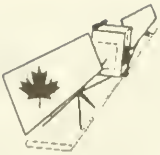
Swath bathymetric map of the Bransfield Strait, Antarctica, showing subsea volcanic features.

Ocean Floor Mapping

The surface area of the Earth, as a whole, is dominated by the ocean basins. Ocean crust is the most dynamic part of the solid Earth—encompassing 70% of Earth's surface area—and has been formed entirely in the last 5 percent of geologic time. As part of a continuous worldwide process, new ocean crust forms at ocean ridges and is destroyed in the deep ocean trenches. Despite its dominance, the ocean floor is largely unexplored and unmapped. Lack of detailed sea floor maps has limited the ability of scientists to address a range of basic questions about how the Earth works as an integrated system. Questions such as what happens when continents break apart, how does continental drift work, how does the ocean floor form, what controls the path of deep ocean currents, what kind of ecological niches exist in the oceans to harbor exotic life forms, and what processes work to shape the ocean floor are fundamental questions that must be answered to have a full understanding of our planet.

Recent advances in technology that uses sound waves to measure distance in water has led to remote sensing systems that can produce detailed sea floor maps. These systems use 120 beams to produce maps up to 15 kilometers wide along a ship track. This system is an enormous improvement over traditional methods, which were limited to single-depth profiles beneath the ship. The resulting maps provide an unprecedented view of undersea features, ranging from small-scale textures of the bottom deposits to underwater fault lines and undersea volcanoes. The sea floor mapping system on the *Nathaniel B. Palmer* allows researchers supported by the U.S. Antarctic Program to explore and map previously unknown regions.

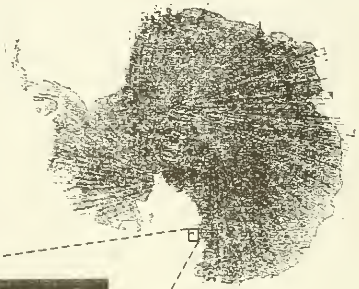
The map of the Bransfield Basin is an example of sea floor maps that are now available. This map was produced as part of a program to study how continents break apart to form an ocean basin and to search for evidence of active submarine hot springs. This project was under the direction of Dr. Lawrence Lawver (Institute for Geophysics at the University of Texas at Austin) and Dr. Gary Klinkhammer (Oregon State University). The region consists of continental crust that has been pulled apart, or rifted, as well as active volcanoes. Molten rock came up through the crust along straight faults to form linear ridges between large volcanoes. The bumpy surface near the volcanoes indicates the presence of mound-shaped hot spring deposits. All of these features are associated with an early stage in the birth of an ocean basin, and at no other place on Earth can one observe this stage of activity. Besides contributing to our general understanding of how ocean crust is formed, ocean basins, especially in their early stage of development, are hosts to major natural resource reserves, including both petroleum and mineral resources. Consequently, understanding the early development of ocean basins will lead to better models for exploration for natural resources elsewhere in the world. The mapping system was also used to pinpoint specific areas that might contain deep sea hot springs. At mid-latitude sites, such hot springs have been found to harbor unique and exotic communities of animals. The Bransfield Strait offers a potential high-latitude site for comparative studies that are needed to understand this new category of ecological system.



RADARSAT: The Antarctic Mapping Project

A NASA Pathfinder

The project will map an area roughly equivalent to that of the United States and Mexico



18 days are required to image the entire Southern Continent

Images like this JERS-1 SAR image of Ross Island, will be available as part of a continental scale digital mosaic.

Antarctica and Remote Sensing: Understanding Earth's Atmospheric Chemistry and Climate Change

Atmospheric chemistry and climate. Human activity affects Earth's global atmospheric environment. The build-up of artificial atmospheric gases and the resulting adverse effect on the stratospheric ozone — which, in turn, controls the amount of ultraviolet radiation reaching Earth's surface — is clear evidence of this impact. Moreover, the coupling between atmospheric chemistry and climate is widely recognized. Many ozone-depleting gases are also greenhouse gases that trap heat in the atmosphere, and ozone itself has an important role in atmospheric radiative forcing.

The Upper Atmosphere Research Program (UARP) in NASA's Office of Mission to Planet Earth supports laboratory research, field measurements, and process modeling to understand atmospheric chemical and transport processes from the upper troposphere to the stratosphere. These processes determine the chemical composition of each atmospheric region (especially regarding stratospheric ozone) and the relationship between chemical composition and climate.

Profound seasonal changes in the Antarctic atmosphere permit measurements that are significant to any global change strategy. UARP has funded balloon and ground-based measurements of stratospheric composition from the three U.S. stations in Antarctica (McMurdo, Palmer, and South Pole stations) and New Zealand's Scott Base. Such ground-based measurements are essential to the international Network for the Detection of Stratospheric Change (NDSC), supported in the United States by NASA and NOAA. Through NDSC, NASA funds various instruments, including a Fourier-transform infrared emission spectrometer at South Pole Station to measure total column abundances of nitric acid, ozone, nitrous oxide, methane, chlorofluorocarbons, and chlorine nitrate, and a microwave instrument at Scott Base to measure profiles and column amounts of chlorine monoxide. Besides ground-based measurements, NASA investigators periodically launch balloons from McMurdo and Palmer stations during the austral spring.

The ice sheet. More than 70% of Earth's fresh water is bound up in the Antarctic ice sheets; if it all melted, global sea level would rise some 70 meters. Over the past century, sea level appears to have risen more than 1 mm per year, with rates possibly increasing over the past 40 years. Thermal expansion of the ocean and gradual melting of small glaciers and ice caps partially explain this rise. Although the polar ice sheets are the obvious sources for the missing water, we still do not know whether the ice sheets in Greenland and Antarctica are growing or shrinking. Consequently, a major goal of NASA's polar research program is to measure the change in volume of these ice sheets.

In 2002 NASA plans to launch the first of a series of satellite laser altimeters to measure directly ice-sheet surface elevation and elevation change over Greenland and most of Antarctica. In addition, the first high-resolution map of Antarctica will be compiled from Synthetic Aperture Radar (SAR) data acquired by the Canadian RADARSAT mission, which NASA launched in November 1995. The resulting maps will show the ice-sheet dynamics in unprecedented detail and will provide baseline data against which future maps can be compared to reveal ice-sheet changes.

To support the satellite measurements, NASA and NSF have established a SAR receiving station at McMurdo Station and radar transponders to calibrate the SAR images at McMurdo and South Pole stations. Data are sent to the NASA-supported SAR facility at the University of Alaska, Fairbanks, for reduction and distribution. NSF supports complementary ground-based studies, such as those by Martin Jeffries of the University of Alaska, on the processes that might be responsible for changes seen in the satellite data.

The table below indicates what percentage of a discipline is supported by which research platform.

Table III-1. Percentage of USAP Research Funding by Discipline and Facility

	McMurdo Station and Field Camps	Amundsen-Scott South Pole Station	Palmer Station	Research Vessels
Aeronomy and Astrophysics	40%	58%	2%	0%
Biology and Medicine	39%	0%	30%	31%
Earth Sciences	70%	4%	7%	19%
Glaciology	88%	12%	0%	0%
Ocean and Climate	21%	7%	29%	43%

1. McMurdo Station

McMurdo Station's total cost in FY 95, including both operations ($77.55M) and science support ($32.41M), was $110M. See Table IV-1 for additional details.

The largest research station in Antarctica, McMurdo is built on the bare volcanic rock of Hut Point Peninsula on Ross Island, surrounded by water with semi-permanent ice cover. The station is critical as a staging facility for logistics support to field camps in the continent's interior and the U.S. station at the South Pole.

McMurdo is by far Antarctica's most valuable high-latitude location for operations and science. In addition to being on one of Antarctica's rare areas of solid ground, making permanent structures possible, it harbors no wildlife to be disturbed, and it has a deep-water harbor that is some 750 miles closer to the South Pole than any other port. Natural ice features adjacent to the station have enabled the construction of aircraft facilities on sea ice (seasonal runway for wheeled planes), on the Ross Ice Shelf (year-round for ski-equipped planes) and at a site known as Pegasus (on glacier ice) for wheeled operations in all but the warmest months. The airlift capability of this station makes the whole of the continent accessible to biologists, geologists, glaciologists, and geophysicists.

McMurdo Station is the site of the Albert P. Crary Science and Engineering Laboratory, a state-of-the-art research facility that supports a wide range of research projects. McMurdo Station is the hub for research in the nearby Dry Valleys, where researchers like Dr. John Priscu from Montana State University discovered cyanobacteria living in the permanent ice of the Dry Valley lakes. Remote field camps dependent on McMurdo support a wide variety of research to understand the Earth and its systems, including the response of the west Antarctic ice sheet research to climate change, long-term ecological studies, ozone research and the connection to biological productivity, and ice core drilling to provide data about paleoenvironments. It also supports the exploration of the geographical frontier, providing the logistics base for remote geological and geophysical research.

In 1993 the McMurdo Dry Valleys area was designated as an NSF Long Term Ecological Research (LTER) site, joining a network of 18 sites where comparative ecosystem research is conducted to determine the common mechanisms controlling change in these systems. Several institutions are involved in this research, which is led by Dr. Robert A. Wharton, Jr., Desert Research Institute, Reno, Nevada. Researchers study the complex dynamics of the polar desert environment, which is characterized by extremes of cold and light-dark cycles.

In addition to research to learn about Antarctica, the Dry Valleys are considered to be the terrestrial environment most similar to conditions on Mars. Ongoing research of mechanical erosion by particles driven by high winds in the dry valleys may give scientists clues to Martian surface processes. Other projects have focused on the ability of simple plant life to exist in niches never before considered to be habitable. Because of these circumstances, NASA and NSF have developed a cooperative agreement to utilize this region for planetary analog studies.

Byrd Surface Camp in central west Antarctic is an example of a remote logistics site capable of supporting many projects. Currently the most important is an aerogeophysics program that uses a specially configured twin otter aircraft to map the ice sheet and the underlying lithosphere to investigate the west Antarctic ice sheet. This involves researchers from three institutions and is headed by Dr. Donald Blankenship and others from the University of Texas at Austin. The west Antarctic ice sheet is the only remaining marine ice sheet (those that have their base below sea level and float at their margins) in the world. There is strong evidence that the disintegration or collapse of marine ice sheets is associated with periods of rapid sea-level rise. The research will help us understand how this marine ice sheet operates and determine if it is vulnerable to future disintegration or collapse. Such an event would have a significant impact on global sea level.

The logistical support capabilities of McMurdo Station allow temporary field camps to be established to focus research on remote parts of the Antarctic interior. In the 1995–96 summer season, one field camp was located at the Shackleton Glacier in the central part of the Transantarctic Mountains. This camp provided support for 12 research teams coordinated by Dr. David H. Elliot (Ohio State University). The projects focused on a range of topics from paleobotany, paleoenvironment, tectonics, sedimentology, and glaciology, with the aim of understanding the complex interactions between biology, climate, and glacial geology in this fossil rich area. The central Transantarctic Mountains, which contain rocks that were formed when Antarctica was part of Gondwana and formed a land link between Australia, South America, and Africa, have features of high scientific value. Among these are a Triassic fossil forest with tree stumps in growth position, which offers the unique chance to study tree density in a forest over 200 million years old. Vertebrate fossils, another special feature of this region, prove the existence of large carnivorous dinosaurs, along with the diverse ecosystem needed to support such large animals during the Jurassic (about 170 million years ago). Abundant fossils of small vertebrate show a wide diversity of life during the Cretaceous (about 100 million years ago).

With the present Antarctic activities, McMurdo is required to operate year-round. It is the logistics hub for all interior U.S. field camps and the lifeline for Amundsen-Scott South Pole Station. Consequently, shutting down McMurdo implies shutting down Amundsen-South Pole Station. Critical research on ozone depletion and UV monitoring at both McMurdo and the South Pole must be conducted during the period of ozone depletion (austral winter). Closing McMurdo in winter would reduce the amount of science, including summer science, that could be done at McMurdo, South Pole, and the camps. The time involved in shutting down the station and reactivating it in spring would shorten summer science by 1 to 2 months out of a season that weather restricts to less than 5 months.

2. Amundsen-Scott South Pole Station

Amundsen-Scott South Pole Station's total cost in FY 95, including both operations ($5.54M) and science support ($10.95), was $16.60M. The amount for operations is relatively low because this station depends totally on McMurdo Station, and some costs attributed to McMurdo Station help support Amundsen-Scott South Pole Station.

Because of its location on an ice sheet 3 km thick at Earth's axis of rotation, its cold dry atmosphere, and its remoteness from centers of human population, the U.S. station at the South Pole has unique and important advantages for conducting world-leading science in earth seismology, astronomy, astrophysics, and atmospheric chemistry

It is the best developed observatory site on Earth for infrared and submillimeter astronomy. Measurements in 1992 showed that the atmosphere over the South Pole is virtually transparent most of the time in the far infrared part of the spectrum, demonstrating that the site is excellent for millimeter- and submillimeter-wavelength radio astronomy. Subsequent measurements, especially by the Antarctic Submillimeter Telescope and Remote Observatory, showed that the site is far better than the next best established site, Mauna Kea, Hawaii, particularly at even shorter submillimeter wavelengths.

The atmosphere above South Pole also is very stable, exhibiting variations on the order of days or weeks, rather than a few hours at sites with a normal 24-hour diurnal cycle. Also, any astronomical object or patch of sky remains at the same elevation for long periods. For many science projects, these factors are even more important than the low opacity. One example is the measurement of the cosmic microwave background anisotropy, which provides insight into the early periods of the Universe. Such measurement requires detecting very small differences (about 1 part in 100,000) in the strength of the signal in different directions, a sensitivity that can be achieved only by making measurements for long periods.

Due to its location on the rotational axis of Earth and its distance from artificial and natural vibrations (Antarctica is almost aseismic), the South Pole is valuable for observation of seismic and atmospheric waves originating anywhere in the world, and it has been used for this purpose for many years. The South Pole is one of only a few high southern latitude stations to study world-wide seismicity. Records from the South Pole of large earthquakes that occur around the world are important for gaining knowledge about Earth's deep interior.

The location on an extensive, deep, and remarkably transparent ice sheet has made possible recent installation of a prototype muon and neutrino detector array that is already the largest on Earth and may prove an effective way to do high-energy neutrino astronomy when an relatively inexpensive cubic-kilometer array is completed. During the 1995–96 season, the Polar Ice Coring Office used hot-water drilling to create four more holes from 1,900 to 2,200 meters deep for the next phase of the Antarctic Muon and Neutrino Detector array.

The Center for Astrophysical Research in Antarctica (CARA), administered by Dr. Doyal Harper of the University of Chicago, continues planned operations, including cosmic microwave background, submillimeter, and near-infrared observations, and in collaboration with NASA's Goddard Space Flight Center, installed a new mid-infrared telescope for testing at the South Pole. CARA, one of NSF's 24 Science and Technology Centers, is headquartered at the University of Chicago's Yerkes Observatory, and represents collaboration among six universities, AT&T Bell Labs, and the Harvard-Smithsonian Center for Astrophysics. The group works closely with other universities, Lockheed-Martin, several foreign institutions, and NASA.

The station also makes possible research that contributes to understanding Earth and its large-scale systems. For example, its remoteness from population centers makes it ideal for observing background constituents of the planet's air and for determining long-term effects of human activities on the atmosphere. Other areas of research include glaciology and atmospheric physics. As an example, light detecting and ranging (LIDAR) instruments measure such atmospheric features as polar stratospheric clouds, atmospheric temperature profiles, aerosols, and the dynamics of the atmosphere at an altitude near 90 km.

Researchers from the U.S. Army's Cold Regions Research & Engineering Laboratory drilled a second access hole to the station's Rodriguez well — an innovative and efficient engineering solution to the station's domestic water needs — and then sent down a collector to retrieve micrometeorites that had fallen on the snow surface, been buried by later layers of snow, and then dropped to the bottom of the water column when the well was established. This unique source of large volumes of micrometeorites is being calibrated for age, changes in composition over time, and variations in the location of their source all valuable data for understanding the history of the solar system.

Amundsen-Scott South Pole Station is an ideal location to test the hypothesis, derived from climate models, that suggests that global warming might increase atmospheric water vapor and thus the amount of precipitation that occurs around the globe. Increased precipitation and subsequent ice sheet growth would eventually lower sea level, counterbalancing increases from other factors such as thermal expansion of sea water and melting of tropical and alpine glaciers. Recent measurements of snow accumulation at South Pole, performed by Dr. Ellen Mosley-Thompson (Byrd Polar Research Center, Ohio State University) have demonstrated that accumulation has increased more than 20% in the last two decades. It is important to know if this increase is due to increases of atmospheric temperature or if other factors, such as changes in atmospheric circulation, have played a role.

Operating Amundsen-Scott South Pole Station year-round is necessary for both operational and scientific reasons. The period of access by air at South Pole is only 3½ months long during the austral summer, and most that period is required just to install and make operational the complex equipment used there. To make significant observations requires that experiments be run in winter, which for many experiments provides the best or only viable conditions. Environmental monitoring experiments, such as air sampling, require year-round operations for their results to be credible. Some services, such as heat and power, would have to be continued in winter to maintain anything like the current level of experimental sophistication, since it would be unrealistic to expect computers and other sensitive equipment to run after cold soaking for 8 months at South Pole temperatures ranging -55° to -120° C. Annual removal and replacement of these systems for use in summer only would be impractical.

Some ionospheric and magnetospheric studies at the South Pole could be done using Automatic Geophysical Observatories (AGOs) similar to those at several remote Antarctic sites. The data could be recovered on annual servicing visits, as is done at the other AGOs. Although AGOs might be adapted for monitoring other than what they now do, most current South Pole science would be lost. Some science might be transferred to other places, e.g., the Clean Air Facility operated at South Pole by NOAA, although the onsite NOAA technicians depend on the central station for their subsistence. For astronomy and astrophysics especially, there is no ready alternative site for most of the projects.

3. Palmer Station

Palmer Station's cost in FY 95, including both operations ($6.07M) and science support ($5.95M), was $12.02M.

Much as McMurdo Station offers entry to the continent's interior for biologists, geologists, glaciologists, and geophysicists, Palmer Station offers entry to the southern ocean for marine biologists and oceanographers. Palmer's laboratories complement research conducted on R/V *Polar Duke*. This station is located in an area of overlapping claims of three countries: Chile, Argentina, and Great Britain. Palmer, while the smallest of the U.S. stations, offers unique opportunities for research. Its location next to the Antarctic Peninsula is significant due to the maritime climate and proximity to large concentrations of birds, mammals, sea life, and terrestrial plants. Since the 1970s, research has been conducted on the population dynamics of seabirds and other marine organisms. Additional long-term research has been instituted for UV radiation, climatology, and worldwide seismic monitoring. Research on the ecology and population biology of seabirds, on adaptations of fish to cold temperatures, and on the effects of UV radiation on marine and terrestrial plants is possible due to the accessibility of the station to these organisms. The laboratories at Palmer Station also enable joint shipboard-station research on the marine ecosystem. Instrumentation at the station provides critical satellite imaging support for research cruises in the Peninsula region and in the Weddell Sea.

Much research at Palmer Station consists of long-term data collection and monitoring. In 1992 the Palmer Station area was designated as the second of NSF's Antarctic Long Term Ecological Research (LTER) sites, the only marine ecosystem in the network of 18 sites. This research focuses on the effects of interannual variation in sea ice extent on the marine community, which includes phytoplankton, krill, and seabirds. Drs. Robin Ross and Langdon B. Quetin (University of California at Santa Barbara) lead this effort, which involves six U.S. institutions. Ongoing LTER studies at the station and onboard ship along the Antarctic Peninsula help in understanding the links between the terrestrial and marine environments. Studies also are performed on the role of marine bacteria in the carbon cycle, the effects of ozone-hole-enhanced UV radiation on grasses that occur only on the Antarctic Peninsula, and the molecular biology of fishes. Long-term monitoring of human impacts focuses on effects of the 1989 fuel spill by an Argentine ship (Antarctica's largest fuel spill) 1 mile from Palmer Station and on the impact of tourist visits on the population dynamics of Adélie penguins.

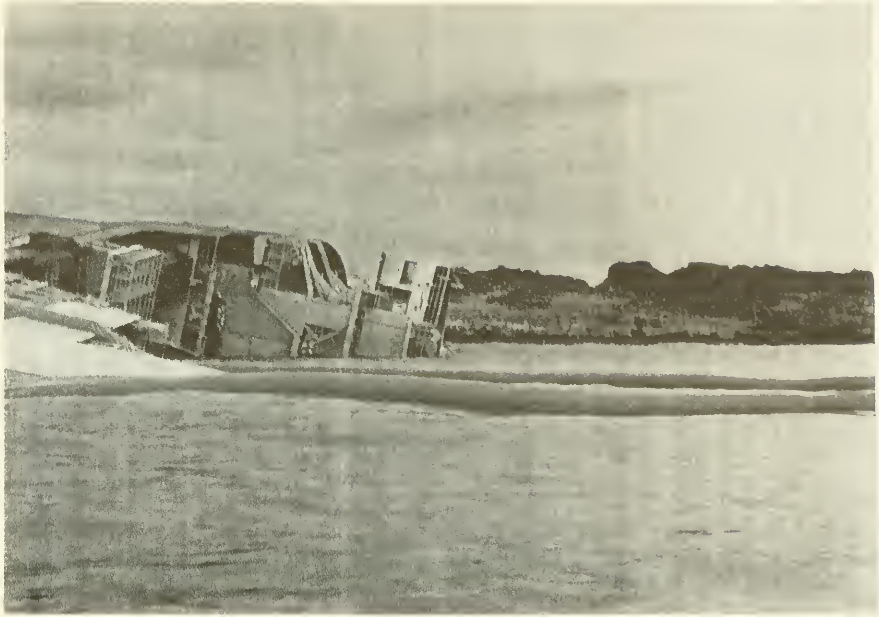
Palmer Station's marine location, high average cloudiness, and remoteness from anthropogenic air pollution sources made it a natural site for a recent study of what is called the cloud-climate feedback effect. Algae in surface waters produce dimethylsulfide, a gas that through chemical reactions forms minute airborne sulfur particles. These particles act as nuclei for the condensation of water droplets, which form clouds. This study for the first time identified hours-long bursts of new cloud-condensation nuclei, which contribute to climatic cooling by increasing cloud cover.

Palmer is the only U.S. Antarctic station that is accessible year-round, providing the opportunity for research on seasonal ecosystem responses to climate change, the entire reproductive cycle of seabirds, and the adaptations of organisms to a polar environment or changes in an ecosystem. Ozone depletion and UV radiation monitoring research must be conducted during the ozone hole from August through November. Long-term research for atmospheric trace gas concentration, UV-radiation measurements, seismic monitoring for earthquake research, very low frequency radio waves, and satellite remote sensing require onsite year-round operators for data collection, processing, and instrument maintenance. These data are transmitted worldwide for study by scientists who never need travel to Antarctica. To maximize berthing for scientists in summer, more of the maintenance and laboratory and stockroom preparation are now done in the austral winter.

4. Research Vessels

The cost for the *Nathaniel B. Palmer* and the *Polar Duke* in FY 95 was $21.82M.

The Antarctic ocean covers an area larger than the area of the continent. Scientific studies in this vast ocean are varied, involve many disciplines, and require research vessels with icebreaking capability. For example, global ocean circulation and thus climate are strongly affected by the formation and flow of deep bottom waters emanating from the Antarctic ocean. Global carbon balance is expected to be significantly affected by southern-ocean phytoplankton blooms. Understanding this carbon balance is important to understanding the formation of atmospheric CO_2 and its contribution to "greenhouse" gases and global warming. Study of the effects of UV



Bahia Paraiso ran aground on 28 January 1989, ripping a 30-meter hole in its side from which fuel began to seep. After drifting for 3 days in the waters near Palmer Station on Anvers Island, the 430-foot-long ship rolled on its side, releasing more fuel into the local marine environment. To control the initial fuel spill a containment boom was put in place around the ship. (NSF photo by Thomas Forhan.)

Marine Fuel Spill Response: A Case Study in Polar Waters

The Argentine supply ship, *Bahia Paraiso*, ran aground and sank in January 1989 near Palmer Station, Antarctica. Although few people were injured, the accident spilled about 200,000 gallons of diesel and jet fuel. The spill caused long-term damage to certain populations in the marine ecosystem, and the prospects for a full recovery are unclear.

The National Science Foundation organized an emergency spill-response team composed of experts from the U.S. Navy, NOAA, the U.S. Coast Guard and private contractors. Arriving at Palmer Station one week after the accident, the team brought 52 tons of fuel-spill response equipment for the initial survey and clean-up. In 1993 a special fund contributed by The Netherlands financed a major Dutch-Argentine salvage effort to remove the fuel that had remained in the ship's tanks.

The study of the effects of the fuel spill on the marine environment consisted of initial sampling begun within days of the ship's grounding, followed by the arrival in 6 weeks of an international, interdisciplinary research team organized by NSF. The initial spill killed as much as 50% of the mollusks and marine algae in the intertidal community. Little effect was seen on subtidal communities. Only a few hundred of the area's 30,000 adult seabirds were observed dead at the time of the spill, but adults bringing food to the nest site exposed their young to fuel-contaminated food. The most severe impact appeared to be in the cormorant colonies, where nearly 100% of the chicks died in a few months after the spill.

Continued studies on various components of the ecosystem over the past 7 years have shown different levels of impact. The intertidal community has been recovering. While the Adélie penguin colonies closest to the spill site no longer exist, changes in overall population numbers remain within the range of natural variability. Active nests of cormorants near the spill have decreased by more 60%, while those away from the spill have remained constant. A steady decline in active kelp gull nests has persisted, suggesting that the initial damage to its mollusk food source drove the bird populations down. Populations of three other species of seabirds were not adversely affected.

Long-term studies are necessary for understanding the impact of fuel spills on different ecosystem components. The establishment of a Long-Term Ecological Research (LTER) site at Palmer Station ensures the collection of long-term data related to the spill. This project builds on the 25-year record of observations on the maritime ecosystem at Palmer Station. Because of this baseline, the project is one of the few to document the impacts of a fuel spill in polar regions. Should future spills occur in the Arctic or the Antarctic, this project will provide valuable information on ecosystem impact and recovery.

In recognition of its role following the spill, in 1993 the U.S. Antarctic Program received a Gold Medal Clean Seas International Award from the government of Malta "for praiseworthy efforts in conjunction with the preservation of a clean marine environment."

penetration into the Antarctic ocean and its subsequent effects on oceanic microorganisms is leading to our understanding of the potential effects of the ozone hole on marine life. Energy exchange between the atmosphere and the ocean, moderated by sea ice, affects regional and global climate; Dr. Martin Jeffries, University of Alaska, Fairbanks, is performing seminal research to better define and describe variations in sea ice types using data collected from the *Nathaniel B. Palmer* and by satellite. Marine geological studies are providing the understanding of the ebb and flow of Antarctica's continental ice sheets over time and are helping to unravel the little-understood tectonic history of the oceanic plates surrounding the continent.

To study this ocean and its global impacts the U.S. Antarctic Program operates two vessels. In most years more than 20 principal investigators from institutions throughout the United States head projects that utilize these research vessels. For example, Dr. John B. Anderson, Rice University, has collected an extensive series of ocean-bottom sedimentary cores to obtain a record of past southern hemisphere glaciation.

R/V *Nathaniel B. Palmer* and R/V *Polar Duke* differ in design and capability. The larger ship, the *Palmer,* is an icebreaking research vessel designed to work year-round throughout the Antarctic ocean. Built in 1992, it is operated for the NSF by a contractor on a long-term charter. This 309-foot research vessel is capable of breaking 3 feet of level ice at 3 knots. With over 4,000 square feet of exterior main deck working area and over 5,500 square feet of laboratory space, the vessel can accommodate 37 scientists. Its operating staff normally consists of 20–24 crew and 6–8 science support personnel. The *Palmer* provides singular opportunities for physical, chemical and biological oceanographers, marine geologists, and geophysicists because it is the only icebreaking vessel in the world dedicated to research in the southern ocean.

Polar Duke supports research primarily in the biologically rich Antarctic Peninsula area. The ship also provides all logistic support for Palmer Station. *Polar Duke* is a 219-foot ice-strengthened research vessel on long-term charter used primarily by physiologists, microbiologists, and oceanographers in the southern ocean and Antarctic regional waters.

5. Summary Analysis of the Stations and Ships

The three stations and two ships give the United States the capability for total coverage in Antarctica. They also enable support of year-round science that is necessary to the solution of many research questions. Where possible, the need for winter data is met using unmanned geophysical observatories and weather stations, of which there are now 54; 15 years ago there were none.

The latitudinal array of the three U.S. stations, spanning 1,800 south-to-north miles from 90°S (South Pole) to 78°S (McMurdo) to 64°S (Palmer), anchors trusted, long-term, year-round data sets in the world's most data-sparse region. It provides opportunities to continue research in complementary Antarctic settings and to correlate changes in the global environment. The critical role of work on the ground in the Antarctic in learning what caused the ozone hole is well documented; less frequently discussed is the fact that the ozone hole was a surprise, and the ability to place outstanding stratospheric chemists in Antarctica within a few months of its discovery depended on the existence of McMurdo as a wintering station.

Operationally, the seasonal cycle varies at the three stations. South Pole's summer, the only time when surface temperatures are high enough to allow airplanes to land, is an intensive period of instrument installation, repair, and replacement and of outdoor construction. In winter, activities withdraw indoors, and science — dependent mostly on instrument-based observations and data collection — is in full swing. The 8½-month wintering is science payoff time at the South Pole. McMurdo is the opposite. Because it supports mostly outdoor science (geology, geophysics, glaciology, biology, the pursuit of which is impractical or impossible in winter) construction, repairs, and maintenance are deferred to winter, where possible, to enable full and efficient support of summer science while keeping the lid on summer population peaks. Palmer, though accessible year-round, also has a summer-winter cycle, timed mainly for support of marine biology focused on the summer-intensive breeding cycle of wildlife.

Nathaniel B. Palmer's winter operations are a response to research demanded for decades. Winter science now is being performed in areas where ships have gone, only briefly, even in summer and never before in winter. *Polar Duke* does year-round science focused on the Antarctic Peninsula area and enables year-round access to Palmer.

Chapter IV
Costs, Future Savings, and Additional Options

A. USAP Science Support/Operations Costs

The USAP budget in FY 95 was $195.8M. Of this amount, grants to university-based researchers totaled $29.1M, research support performed by contractors and the military totaled $42.1M, and operations and logistics provided by contractors and the military totaled $124.7M.

> **Research Grants** (15%): awards to university-based scientists for salaries and university overhead, specialized research equipment unique to the needs of the grant, research in Antarctica, completion of analysis at home institutions, and publication of results.
>
> **Research Support** (21%): research ship and aircraft operations, laboratories, instrumentation, technicians, equipment, field camps, field safety equipment and personnel, transportation of scientists and their cargo. These costs in other federally funded programs typically are identified as science costs.
>
> **Operations and Logistics** (64%): operation and maintenance of 7 LC-130's, 6 UH-1N twin engine helicopters, 2 supply vessels (a freighter and a tanker), an icebreaker, chartered C-141 and C-5B airplanes, management and operation of the three Antarctic stations, planning, support personnel, support functions (food, power, water, shuttle buses, etc.), vehicle and construction equipment operation and maintenance, maintenance of structures in Antarctica and at staging areas in Christchurch, New Zealand, and Punta Arenas, Chile, architecture and engineering, construction, and renovation of facilities.

Historically, NSF budgets have labeled USAP contractor and military activities as "operations" and research awards to institutions as "science." But the contractor and the military perform some functions that an NSF grantee would pay for out of the grant if the research were performed away from campus elsewhere than in the Antarctic. This USAP managerial initiative is employed to save costs and increase mission effectiveness.

For example, the contractor buys and ships equipment and consumables for the Antarctic laboratories, saving money because of volume purchases and bulk shipping, and it negotiates discounts for airline tickets and air freight. Buying commonly utilized equipment and materials in bulk in advance and sending them to McMurdo on the once-per-year cargo ship, instead of granting funds to investigators to buy them separately and fly them in, reduces costs dramatically. In transport alone, to fly cargo from Christchurch to McMurdo in an LC-130 (making a ski landing) costs $3.63 per pound. Using a fully loaded C-5 (the most efficient air carrier between Christchurch and McMurdo) the cost is $1.05 per pound. The annual ship takes cargo from Port Hueneme, California, to McMurdo, and returns back, for $0.17 per pound. The heavy icebreaking capability of the DOT/U.S. Coast Guard is invaluable because it allows cargo ships to access McMurdo Station. As ship transport is more than ten times less expensive (per unit weight) than air transport, this national icebreaking capability supplied by the DOT/U.S.

Coast Guard on a partial reimbursement basis enables the USAP to function far more cost-effectively.

Cost accounting associated with NSF's effort to control and forecast costs, and to improve research planning on a project-by-project basis, enables the USAP to identify research-support activities performed by the contractor and the military that other Federal research programs would describe as research costs. In FY 95 these research-support costs were 25% of USAP operations and logistics.

Table IV-1 shows USAP costs for each major facility. Table IV-2 shows the Antarctic research expenditures of NSF and other Federal agencies. Antarctic field research performed by these agencies further reduces the USAP operations-to-science ratio.

Operational improvements in the USAP have increased the capability for doing science, aiding in reducing of the operations-to-science ratio, and they have contributed to the achievement of science-related goals, in particular the reduction of environmental impact. In the 25 years since NSF was given the responsibility as the single point manager of the USAP, there has been continual improvement in efficiency of operations and cost savings. The following are examples of recent operational improvements.

- Tasks such as inventorying, renovating facilities, and major vehicle maintenance have been shifted to the months-long winter isolation, when demand is down and more time is available for those functions. As a result, the number of support staff during the peak summer months has been reduced by over 200 persons.

- Partly because of the above, the number of scientists and technicians has been increased 65% since 1990.

- In the last decade, laboratories and support facilities in Antarctica have been upgraded to become capable of cutting edge experimental and observational research; previously, much of the research was limited to observations and sampling.

- New research platforms, such as 28-million-cubic-foot balloons that circumnavigate the Antarctic at an altitude of 120,000 feet supporting NSF/NASA space research and specialized research aircraft supporting sophisticated geophysical research, are now commonplace. They were not in use 10 years ago.

- Energy conservation and replacement of older systems have reduced fuel consumption by 1.5 million gallons per year, saving $1.8M annually. The reduced consumption has reduced the emission of atmospheric pollutants and has reduced the danger of fuel spills.

- The Program has implemented a "pack it in, pack it out" policy with regard to solid and hazardous waste, resulting in the removal from Antarctica of over 5 million pounds of waste each year. Seventy percent of the waste is recycled; by comparison, the U.S. domestic average for recycling waste is 22%. The waste management cost, $3M annually, has been offset by cost-efficiencies in other areas.

Table IV-1. USAP funding for science and support, by facility, FY 95

	Operations and Logistics	Science			Totals
Palmer		Research Support	USARP*	Total Science	
Station Operations	1.69				
Facilities Maintenance/Engineering/Construction	0.82				
Logistics	3.56				
Direct Research Support		1.15	4.80		
Total Palmer Station	6.07			5.95	12.02
South Pole Station					
Station Operations	2.25				
Facilities Maintenance/Engineering/ Construction	0.84				
Logistics	2.44				
Direct Research Support		4.25	6.70		
Total South Pole Station	5.54			10.95	16.50
McMurdo and Field Camps					
Station Operations	42.07				
Facilities Maintenance/Engineering/ Construction	4.81				
Logistics	30.68				
Direct Research Support					
McMurdo Station**		2.00	3.32		
Field Camps		17.15	9.95		
Total McMurdo Station	77.55			32.42	109.97
Research Vessels		17.52	4.30	21.82	21.82
Off-Continent Costs	35.53				35.53
Totals	124.70	42.08	29.07	71.15	195.84

*United States Antarctic Research Program: budget line for research grants to institutions

**Nearly all of this amount represents costs of operating the Crary Lab in McMurdo Station.

Table IV-2. Federal support of Antarctic science, by agency, FY 95

National Science Foundation	71.14
National Aeronautics and Space Administration	6.00
National Oceanic and Atmospheric Administration	4.00
U.S. Geological Survey	2.00
Department of Energy	0.14
Smithsonian Institution	0.12
Total U.S. Support of Antarctic Science	83.40
Total U.S. Support of Antarctic Operations and Logistics	124.70

Summary of the Major USAP Cost Centers

McMurdo Station accounts for more than half the USAP budget — 56% — because it is America's operational hub for Antarctica — the gateway to the interior of the continent and the lifeline for South Pole Station. McMurdo is the central facility for aircraft, field party outfitting, surface vehicles, waste management, fuel storage, shops, warehouses, communications, and onsite program administration. It also has major science laboratories. The station's location on Winter Quarters Bay at the end of Hut Point Peninsula on Ross Island exploits natural features unmatched elsewhere: a sheltered deep-water harbor hundreds of miles farther south than any other, level glacier ice and seasonally stable sea ice enabling construction of a skiway and low-cost runways, and ice-free land (unoccupied by wildlife) on which to build facilities and store supplies. Because of this combined air-sea port facility, flights coming from outside of Antarctica can be limited to carrying personnel and priority cargo. Ships deliver 95% of USAP's fuel and cargo, at a per-pound cost that is 92% to 98% less than the cost of air cargo.

The two other stations, Palmer and Amundsen-Scott, are more dedicated to the direct performance of science. The combined cost of these two stations is approximately 15% of the total cost of the Program.

The work at the stations is complemented by the two research vessels, R/V *Nathaniel B. Palmer* and R/V *Polar Duke*. The *Palmer* is dedicated to the support of marine geology, geophysics, physical oceanography, and marine biology in the southern ocean and has no logistics role. The *Duke* supports marine biology and oceanography and provides logistics for Palmer Station. The cost of operating both vessels is 11% of the Program.

Off-continent costs are for the headquarters functions of the civilian contractor, Antarctic Support Associates (Englewood, Colorado) — a joint venture of EG&G Inc. (Wellesley, Massachusetts) and Holmes & Narver Inc. (Orange, California) — and DoD's part in the program (Construction Battalion Center Port Hueneme, and Naval Air Weapons Station Point Mugu, California; Stratton Air National Guard Base, Schenectady, New York; and Christchurch, New Zealand). Off-continent costs are 18% of the Program cost.

B. Projected Savings in Program Operations

B1. Transition of Functions: Navy Base Support to Civilian Contract

Present management objectives have focused on streamlining the Program's operational and logistics costs to realize efficiencies and enable more effective support of science. The management policy is to privatize, to the extent possible, the functions performed by the DoD, such as station maintenance, food services, and vehicle operations and repair. This objective received added impetus with the Navy's plan, stated in 1993, to withdraw from the U.S. Antarctic Program.

Table IV-3 summarizes the functions that have been or will be transferred to civilian contract support and the expected annual cost savings.

Table IV-3. Cost factors of USAP transfers from military to civilian contractor

Function Functions Already Transferred	Transfer Date	NSFA Cost Note (1)	Contractor Cost Note (1)	$ Savings
Power Plant	1981	NA	ITT Transition	NA
Water Plant	1985	NA	ITT Transition	NA
Heavy Veh. Maintenance	15-Oct-87	NA	ITT Transition	NA
Food Services	1-Oct-92	$2.9M	$2.5M	$0.4M
Term Ops (2 increments)	1-Oct-92	$3.8M	$4.1M	$0.3M
Comms - FOCC	1-Oct-93	NE	NE	NE
Public Works	1-Oct-93	$1.6M	$0.7M	$0.9M
Station/Haz Waste	1-Oct-93	$1.3M	$1.3M	$0.0M
Fuels Operations	15-Feb-94	$1.0M	$0.5M	$0.5M
Supply/Materials	17-Feb-94	$3.0M	$1.4M	$1.6M
Crash/Fire Services	30-Mar-94	$1.3M	$1.2M	$0.1M
Janitorial/Billeting	1-Oct-94	$0.5M	$0.5M	$0.0M
Ambulance Service	1-Oct-95	incl. in M/D	incl. in F/D	
Comms - Field Radios	1-Oct-95	NE	NE	NE
SUBTOTAL		**$15.4M**	**$12.2M**	**$3.2M**
Functions to be Transferred				
Helicopter Services	Oct-96	$5.0M	$3.5M	$1.5M
NX/PO	Jan-97	$0.6M	$0.7M	(0.1M)
Air Traffic Control	Oct-97	$1.8M	$0.9M	$1.0M
Medical/Dental	Oct-97	$1.0M	$0.7M	$0.3M
Meteorology	Oct-97	$1.5M	$1.0M	$0.5M
Armed Forces R/T	TBD	NE	NE	
Comms - Operations	TBD	$2.3M	$1.0M	$1.3M
SUBTOTAL		**$12.2M**	**$7.8M**	**$4.4M**
TOTALS		**$27.6M**	**$20.0M**	**$7.6M**

This chart illustrates the actual and estimated annual savings that result from the transition of functions from DoD to civilian contract support (NA=Not available; NE=Not Estimated; TBD=To Be Determined; NX/PO=Ship's store and Post Office)

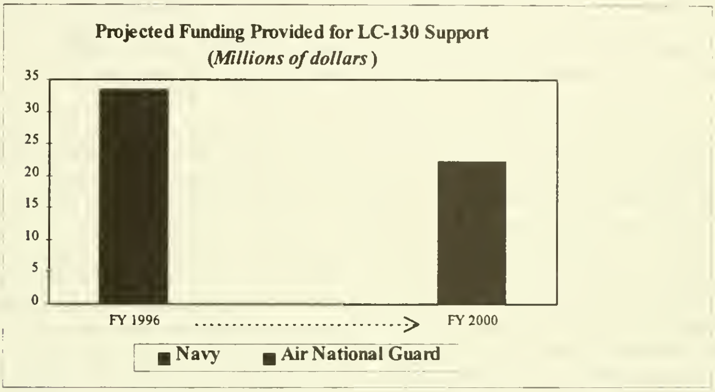
B2. Single Point Management of the Fleet of LC-130's

In addition to the savings to be had in transferring tasks from the military to the private sector, specific transfers of responsibility within the military can also provide appreciable cost savings. The ski-equipped C-130 (LC-130) is the only aircraft of its type in the world. There are only two operators of the LC-130, a Navy squadron based in Pt. Mugu, CA (VXE-6), and an Air National Guard squadron based at Stratton Air Force Base in Schenectady, NY (109th AW). VXE-6 operates and maintains NSF's fleet of LC-130s. Single Point Management by the Guard will consolidate the operation and maintenance of these two squadrons under a single DoD manager to meet Arctic and Antarctic logistics and science support requirements.

Single point management of these airplanes will reduce costs by eliminating duplicate organizations at all levels, reducing personnel and training costs, standardizing equipment and maintenance and operating procedures, and streamlining the planning and scheduling of polar airlift. The USAP will reimburse the Air Force only for its support to the Antarctic program. OPP and other NSF units reimburse the Air Force (Air National Guard) for its support work in the Arctic.

Anticipated cost savings are illustrated in Figure IV-1.

Figure IV-1. Anticipated cost savings resulting from single point management of USAP airplanes



B3. Additional Efficiencies

Advanced technology, and remote operation especially, can maximize the scientific return of the investment in Antarctica. This framework has two major components. They are:

> **Advanced Communications and Computers**: Some USAP funding will be invested in communications capabilities. This will provide electronic access to the Antarctic sites and instruments from any university. For example, instruments can be monitored and adjusted by scientists at their home institutions or laboratories. Investigators in Antarctica, summer or winter, will be able to confer with colleagues anywhere in the world. Researchers will be able to carry out some kinds of observations in Antarctica without ever leaving their U.S. laboratory.

Automated Data Gathering: Automated instrumentation will complement the data gathering and experiments carried out at the manned Antarctic stations. Instruments have been and continue to be developed that operate without human intervention to gather data in regions not readily occupied.

B4. Summary of Cost Saving in Operations

Since 1992, the transition of functions from the Navy to civilian contract has resulted in annual savings of $3.2M.

Transition of the remaining functions of the Naval Support Force Antarctica and the helicopter functions of Antarctic Development Squadron 6 (VXE-6) may potentially save an additional $4.4M per year. Placing the ski-equipped C-130s with a single manager is estimated to have a further potential annual savings of $9.7M by 2000.

Therefore, estimated annual savings in operations from further transition of functions from the Navy to contract support and the Air National Guard sum to $14.3M annually by 2000. Additional savings are anticipated from application of the previously mentioned technologies, but the payback from such investments are difficult to assess at this time.

Examining those options and their consequences in detail both goes beyond the expertise of the NSTC working group and requires more time than was available for the present study. Therefore, the NSTC recommends that the Foundation convene an external panel of experts, some of whom have direct management experience in operations in hostile environments, to examine options that accomplish program goals at the lowest cost. This panel should explore how an optimal set of scientific and geopolitical objectives can be achieved with likely out-year budgets (constant manpower, dollar flat, or 10% reduction). The composition of such a panel requires knowledgeable scientists and international policy makers as well as experienced managers. This panel should be free to examine all options to provide the U.S. with the best program in the Antarctic at a given budget level. This study obviously requires considerable time and should be initiated as soon as possible. Timely input to the budget process, starting with the FY98 budget, is highly desirable.

C. Options for Large-Scale Cost Savings

In addition to cost savings from increased efficiencies, further cost reduction can be achieved by reducing the scope of the activity or, possibly, by sharing costs with other countries. Congress asked that options such as less than year-round human presence, closing one or more stations, and increased internationalization be examined. These are discussed below.

C1. Operations

In Chapter III, Table IV-1 shows costs.

South Pole. Closing South Pole Station and removing the USAP logistics that support it would save $16.5M per year. The one-time cost to remove the station would be at least $40M. Recovery of funds by selling assets is not expected since the items are approaching the ends of their service lives.

Most of USAP's astronomy, astrophysics, and aeronomy are performed at this station and would end. NOAA's South Pole Climate Monitoring & Diagnostic Laboratory (one of just four worldwide) would be closed, as would the onsite USGS seismic observatory. NASA would not install its prototype closed-cycle processing system for food, water, and waste intended for later use in space.

Also, South Pole is a hub for research on the high Antarctic plateau. Sites that are accessed via the station would be closed because removal of the South Pole skiway eliminates the station as a landing place and fuel depot for air operations. These sites include some Antarctic Geophysical Observatories (AGOs), Antarctic Weather Stations (AWSs), and glaciology and geology projects requiring access to the continental interior farther from McMurdo than South Pole.

The loss of AWSs would reduce acquisition of climate and weather data from this extremely data-sparse region and would break the continuity of the data sets, further increasing the uncertainty of global models that attempt to quantify and understand Antarctica's dominant force in global climate and climate variability. Anthropogenic climate impact will be seen first and strongest in polar regions; testing of climate models for predictability require long-term continental data. At South Pole itself, precipitation has increased 20% in the last decade, and other atmospheric changes indicate the climate is changing there; this line of research would be terminated. The loss of the AGOs would inhibit U.S. mapping of the cusp region of the ionosphere, which complements the space physics observations of NASA, NOAA, and DoD. The special location of South Pole relative to the geomagnetic field that funnels particles and fields into the ionosphere permits research on the sun's impact on the near-earth environment, so "space weather" research would be impacted. NOAA's long-term record of ozone and other greenhouse gas measurements would end. Loss of UV monitoring would be significant because the South Pole is at the center of the ozone hole. Loss of the seismic station would create a void in the global coverage (the South Pole sensor is recognized for probing remotely the Earth's interior and for monitoring earthquakes and nuclear weapons testing). Finally, the investment in AMANDA, the prototype of a new astronomy using the ice sheet to detect neutrinos, would be lost. Closure of South Pole would leave Russia as the only country with a station, Vostok, in the Antarctic interior.

On 9 March 1996 the Department of State provided to the National Security Council a memorandum (Appendix II), cleared by the Department of Defense, stating that it is "essential that the United States continue to maintain an active and influential presence in Antarctica, including year-round operation of South Pole Station." *The NSTC concurs and strongly advises against the option of closing South Pole Station at the current level of investment.*

As evidenced by researchers' large and growing interest, South Pole Station's contribution to U.S. science is significant. The NSTC feels that its closure would be a practical and symbolic loss to the global reach of U.S. science.

Other USAP options consistent with the DoS statement of foreign policy and national security interests are (1) reduce McMurdo but keep it open year-round;[*] (2) close Palmer; (3) eliminate one or both research vessels; or combine parts of these options. Science terminated by implementing the options would be in the amounts shown in Table III-1.

McMurdo. Eliminating all the research camps supported from McMurdo would save approximately $60M per year. This means eliminating virtually all of the science associated with McMurdo in Table III-1 and reducing McMurdo to a service port for the South Pole station. The helicopter and Twin Otter contracts that support some of the camps could be terminated. The LC-130 capability that supports the rest of the camps could be reduced roughly to that required to supply South Pole (because of fixed costs and safety needs, reducing flight-hours may not reduce costs proportionally). McMurdo's field outfitting facility and much of its laboratory space would become unnecessary. The station's population would drop considerably. USAP grants to universities would be eliminated to match the reduced capability to support research.

The cost of terminating these functions was not calculated. However, the cost to remove all of McMurdo in compliance with the Antarctic Treaty and U.S. law regarding abandonment of facilities would exceed $200M. Shutdown costs might be offset by selling capital items; some of the vehicles and other usable equipment are standard or modified factory issue and probably marketable. Some of the LC-130s might be sold, although the United States has never licensed these uniquely capable airplanes to foreign governments.

McMurdo is the facility that enables research to be carried out almost anywhere in Antarctica. The infrastructure is based on air support. Scientists are placed in regions such as the Dry Valleys, the west Antarctic ice sheet, and the Transantarctic Mountains — where the research must be carried out — rather than being restricted to the stations. The air support also enables shorter field deployments, limited to the time actually required at a research site. These two features make it possible for highly regarded scientists to perform research in Antarctica without committing to unduly long absences from their research institutions.

USAP aeronomy & astrophysics would be reduced significantly, biology would be reduced significantly, terrestrial earth sciences would be virtually eliminated from the USAP, glaciology would be nearly eliminated, and oceans & climate would be reduced significantly (see Table III-1). Research lost near McMurdo would include UV impacts on biota, biomolecular aspects of genetic evolution, nearshore oceanography, and marine biology including physiology of deep diving birds and mammals. The loss from the Dry Valleys would include the Long Term

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[*] South Pole Station requires McMurdo Station for logistics. NSF's safety assessment for South Pole does not identify a way to deliver personnel or equipment to South Pole in an emergency other than by LC-130 from McMurdo. (USAP has never landed a plane at the South Pole in winter; the extreme cold probably would make the airplane incapable of leaving until the following summer.)

Ecological Research site, the analogs-to-Mars research, and geophysical and glacial-geology studies related to Antarctic climate and its global impact. The remote field camps include Vostok ice coring with the oldest ice core climate record, the future of the west Antarctic ice sheet and its impact on sea level, the aerogeophysics, and most geology and glaciology.

Abandoning research camps supported from McMurdo would have a grave impact on our ability to gain understanding of Antarctica's role in global processes. Since the Antarctic is the only place in the world where this research can be conducted, the research camps must be continued. This option would eliminate a major part of all of our research program. We strongly advise against this option, unless the USAP budget is severely reduced.

Palmer. Abandoning Palmer Station would save about $12M per year. R/V *Polar Duke*, which both supplies Palmer and supports science integrally with it, would be diverted to other research, laid up for portions of the year, or terminated. Research grants would be terminated or adjusted accordingly.

Palmer is the smallest and farthest north of the three U.S. Antarctic stations. It supports only a few research camps, does not use aircraft, is much closer to South America than McMurdo is to New Zealand, and by Antarctic standards has a moderate climate. It is accessible by ice-strengthened ship almost any time of year and is provisioned by R/V *Polar Duke* out of Chile. The station is within the narrow wedge of the Antarctic to which three countries — Argentina, Chile, and Great Britain — assert overlapping territorial claims, so it has a significant role in stabilizing international Antarctic relations. Palmer's maritime climate places it close to large concentrations of birds, mammals, other sea life, and terrestrial plants; research at Palmer focuses on this important part of the world's ecosystem.

The station is crucial to USAP science; it supports about one-third of the program's biology and ocean and climate research (Table III-1). Research loss would be the ongoing 30-year Palmer-area ecological and environmental database and knowledge base. Subjects include adaptations of organisms, physiological ecology and population dynamics, environmental studies of *Bahia Paraiso* fuel spill effects, UV and LTER site measurements of the effect of interannual variations in sea ice on marine ecosystems, climate-atmosphere comparisons, and El Niño relationships to marine air temperature, sea surface temperature, and sea ice extent.

A one-time decommissioning cost, estimated at $15M, would be incurred to meet the requirements of U.S. law (45 CFR 671, Antarctic Conservation Act) and the Antarctic Treaty; decommissioning would take several years. Closing Palmer would gut a large, valuable part of the research program while saving a small fraction of the USAP budget; the NSTC strongly advises against it.

Research Ships. Retiring both research vessels would save $15M and would reduce the research effectiveness of Palmer Station, which would be supplied by chartered ship instead of working in conjunction with R/V *Polar Duke*. The research ships are under long-term charter; they would be disengaged through termination-of-lease agreements costing the Government approximately $11M per year for the life of the lease.

Loss of the research ships would remove from a largely unexplored ocean all studies in marine geology and geophysics, air-ocean-ice interchange of energy as it relates to climate and impact of greenhouse gases, ocean circulation and global climate, and biological studies of a productive ocean area that feeds nutrients to oceans around the globe. The *Nathaniel B. Palmer* is the only research icebreaker of any nation that works year-round in the Antarctic. This research campaign, begun only four years ago when the ship was commissioned, is providing physical, chemical, and biological winter data from the Antarctic that are invaluable to understanding ocean ecosystem function and global ocean circulation. As discussed above, Palmer Station now depends on *Polar Duke* and would need to be supported in some other way.

Again, we cannot support this option. Indeed, none of the major program reductions inherent in eliminating one of the major USAP assets is recommended as long as the budget is not drastically reduced.

C2. International Cooperation

International cooperation in the USAP is extensive in both research and operations. It usually involves in-kind contribution of national strengths to the realization of research goals beyond the capability of a single nation. These goals generally are achieved by (1) performing similar work in different places (collecting weather data, for example) and sharing the results as required by the Antarctic Treaty or (2) performing an intensive project in one place (an example is the 1996–1998 Cape Roberts project, which will drill an ocean-bottom sedimentary core from a platform on coastal sea ice) in which each participating nation delivers a negotiated component of the project. In a very few instances, the United States has been reimbursed for services to another nation's Antarctic program, such as refueling a research station from a U.S. ship, or by providing unscheduled but nonemergency airlift.

Opportunities for international cooperation are explored and implemented regularly. Formal mechanisms include the Scientific Committee on Antarctic Research (SCAR) of the International Council of Scientific Unions (nongovernmental), the annual Antarctic Treaty consultative meetings (government-to-government policy decisions), the Council of Managers of National Antarctic Programs (COMNAP, a U.S. initiative, administered by the American Geophysical Union), the Council's Standing Committee on Antarctic Logistics and Operations (SCALOP) and its Antarctic Managers' Electronic Network (AMEN: electronic mail and data exchange and a home page on the World Wide Web), and the New-Zealand based International Center for Antarctic Information and Research (ICAIR), which is developing a master Antarctic Data Directory and other international Antarctic information services in close collaboration with the USAP and other Antarctic Treaty nations.

International funding of a jointly owned facility in Antarctica appears never to have occurred. Even the satellite nations of the Soviet Union, such as Poland, established independent stations supported by Soviet logistics. The European Community currently is planning a joint station, named Concordia, for East Antarctica in which the major research goal is ice core drilling. The

USAP is not a participant in this planning, but has been asked to provide logistics through McMurdo on a cost-reimbursable basis.

Of the USAP facilities, McMurdo appears to have the most potential for cost-reimbursable international collaboration. Following is a discussion of international prospects for Palmer and McMurdo. South Pole Station's options and recommendation for international cost sharing are discussed in Chapter V.

Palmer. Palmer Station is in the Antarctic Peninsula region, which has Antarctica's greatest concentration of Antarctic programs and stations of other nations. This region would seem ripe for international cost sharing. A commercial operator has tried to convince governments of the possible savings if they were to supply their stations using a single freighter rather than each deploying its own ship. The firm, however, has been unable to establish business. Governments operating in the region tend to maintain self-sufficient Antarctic operations to support missions unique to their research requirements, to meet the "substantial scientific activities" threshold for Antarctic Treaty consultative status, and to support their territorial claims.

NSF on occasion purchases passage from tour ships operating between southern South America and the Palmer Station area, saving crossings of the Drake Passage by its own vessel. Because *Polar Duke*'s primary role is research support in conjunction with Palmer, and because its size was determined by these research and logistics needs, diversion of the ship to the support of other nations' needs would reduce its performance as a research tool for U.S. goals; both the ship and the station are operating at capacity in support of U.S. research.

NSF now has 12 years of operating experience with the *Polar Duke*/Palmer Station pair and has found them correctly sized for most research needs; NSF's procurement of the *Duke*'s replacement ice-strengthened research ship *Laurence M. Gould*, to begin long-term charter to the USAP in 1997, specified "a *Duke*-like ship at a *Duke*-like price." In fact, the outcome will be a new, purpose-built ship from a Louisiana yard delivering a more capable vessel at a lower price.

McMurdo. McMurdo, occupying Antarctica's most desirable real estate for a high-latitude research and operations base, is USAP's most intensive center of international in-kind cost sharing. The long-standing partnership between the United States and New Zealand, whose Scott Base is 2 miles from McMurdo, is unmatched among all the Antarctic Treaty nations. This cooperation provides significant cost savings and operating advantages through extensive sharing of flights, weather forecasting, helicopter operations, ship cargo movements, cargo handling, research planning, communications, fuel storage, hazardous waste removal, and emergency plans including search and rescue.

Italy in recent years has become another steady partner, with shared helicopter operations, C-130 loads between New Zealand and Antarctica, station refueling on a cost-reimbursement basis, and research planning; Italy's modern research station Terra Nova Bay is on the coast of the Ross Sea 175 miles north of McMurdo.

Russia and the United States intensified cooperative science and operations through McMurdo during the breakup of the former Soviet Union; the major new achievement has been shared support of Russia's year-round station Vostok, in the Antarctic interior 800 miles west of McMurdo. The Russians are drilling the world's deepest ice core at Vostok, and the cooperative agreement provides U.S. access to this scientifically valuable core in return for six LC-130 flights annually between McMurdo and Vostok for personnel exchange. The trade is financially advantageous to the United States in that the cost of an ice coring project is measured in the millions of dollars where the cost of the LC-130 flights is in tens of thousands.

Germany, France, Japan, and Australia have worked cooperatively with the USAP in pursuit of specific research projects over the years. Nearly every Antarctic Treaty nation has exchanged scientists with the USAP at one time or another.

Additional international sharing of the cost of the McMurdo logistics and research support capability appears feasible, consistent with further growth in non-U.S. research in the Antarctic interior and the Ross Sea region of Antarctica.

Chapter V
Amundsen-Scott South Pole Station Renovation

A. Establishment and Early Facilities

Aside from the expeditions in 1911 and 1912 by Roald Amundsen (Norway) and Robert F. Scott (England) and the overflight in 1929 by Richard E. Byrd (U.S.), the geographic South Pole remained unoccupied until 1956, when the U.S. established a research station for the International Geophysical Year. The Amundsen-Scott South Pole Station is the only facility that has been continuously operated in the Antarctic interior since the IGY, a period of 39 years. Amundsen-Scott is also distinguished by having acquired 39 years of continuous scientific data sets, an extensive research program covering several disciplines, and the political and symbolic value of its special location. (The North Pole is unsuitable for a continuously occupied facility because its ocean position consists of seasonably unstable and rapidly moving sea ice only a few meters thick.)

Structures built for the IGY were prefabricated huts of insulated canvas over wood frames (called Jamesways), intended to last 3 years. Eighteen people wintered over at the South Pole in these huts. In 1962 wooden, insulated, prefabricated “T-5” buildings and steel arch tunnels covering fuel bladders and station supplies replaced the Jamesways. By 1967, 18 feet of drifted snow had damaged the arches and buildings.

Today’s geodesic dome and steel arches and the structures under them — the current core South Pole Station facility — were designed in the mid-1960s and procured, delivered, and erected between 1969 and 1975. The 1975 station was built to house 33 people, summer and winter, within the protective dome. By 1976 scientific requirements had led to the construction of additional Jamesway berthing and a Clean Air Facility. Subsequent pressure from the science program required retaining the Jamesways, originally temporary housing for builders, as a summer camp. In the late 1970s research needs led to additional temporary structures.

B. Status Today

The present science program at the South Pole and the necessary operations and maintenance staff to support it require a summer population of 140, nearly four times beyond the station design.

The facilities built in 1975 are near the end of their design life. Inspections in 1993 identified over 300 building and safety code deficiencies, of which one-fourth were viewed as a threat to life or health. Most safety concerns have been addressed, but deficiencies remain in industrial areas, particularly the garage and shop facilities. Brown-outs have damaged scientific equipment and resulted in the inability to offer support to proposed high-quality research. Waterline and sewer failures have required emergency repairs, diverting effort from planned maintenance and research project support.

Administrative and engineering controls are being employed to reduce safety risks in the industrial areas. For example, carbon monoxide monitoring in the garage has reduced the exposure of workers by indicating maximum allowable levels during a shift; these ceilings have reduced worker productivity by 30%. Additional controls will be required with the further aging of the facilities.

C. Redevelopment Plans for Amundsen-Scott South Pole Station

The extreme climate, the station's isolation (McMurdo is 838 miles away), and the inability to land airplanes during the eight coldest months dictate that a facility at the South Pole be designed as if it were to carry people on an interplanetary journey. Structures, power, water, light, cooking, repair, and communications at the South Pole are life-support systems, not conveniences. These requirements, combined with the limited construction season at the South Pole, mandate long lead times for planning. Preparation for replacing the station was begun in 1990.

Planning started with architectural and engineering designs and studies of environmental impact. It continued with experimentation in materials and practices and included prototype construction. Any future facility would correct current deficiencies and improve operational infrastructure. At a minimum, the redevelopment would provide a safer working and living environment, replace thermally inefficient buildings and inadequate utility systems, and supply platforms for science. In addition, the NSF believes that the redevelopment should:

- minimize operations personnel and maximize science personnel
- minimize environmental impact by supplying effective systems for managing solid and hazardous wastes
- optimize use of existing facilities
- minimize impact of drifting snow on infrastructures
- achieve a 25-year station life

C1. First Options

In 1994 NSF initiated a series of three reviews of the plan that had been advanced by its Office of Polar Programs. Based on anticipated science and support requirements (e.g., augmentation of the balloon-launch facility and expansion of astrophysics research), the Office had suggested replacing the station with a larger one. The initial plan called for a 150-person station. A Peer Review Panel, a Non-advocate Review Panel chaired by Palmer Bailey, the Deputy Director of the U.S. Army Cold Regions Research Engineering Laboratory, and a Blue Ribbon Panel chaired by H. Guyford Stever, a former NSF director and Presidential Science Advisor, endorsed the plan and suggested improvements.

Following these reviews the National Science Board in November 1994 then examined a more-detailed Program Development Plan. The Board recognized that many demands were being placed on the NSF facilities budget and thus asked that other options also be considered. NSF responded with several alternatives. (See Table V-1.)

Table V-1. Station size options for South Pole Redevelopment

Station Option	Summer Science	Population Non-science	Winter Population Total	Estimated Cost
25-person Station	**5**	**20**	**25**	**$90M**
***75-person Station**	**32**	**43**	**28**	**$150M**
****110-person Station**	**58**	**52**	**28**	**$170M**
****110-person Enhanced**	**58**	**52**	**28**	**$181M**
150 person Station	**93**	**57**	**50**	**$200M**
200-person Station	**135**	**65**	**50**	**$255M**

*** Estimates for 75-person station are extrapolated from other station estimates.**

****Cost estimate for 110-person and 110-person enhanced are based on 1200 separate cost elements.**

C2. NSF's Choice

In March 1995, still concerned about keeping the cost down but also desiring to sustain the current scientific effort, the Board approved continued planning for the 110-person "Enhanced," which initially would accommodate 110 people in summer and 28 in winter. The $11-million additional cost of the enhancement, as compared to the 110-person station, allows for cost-effective future expansion to support 150 people by providing for earlier construction of systems or areas that would be difficult or costly to expand later, such as the power plant, the galley, water production and treatment facilities, and a multi-purpose room. The cost to go from the 110-Enhanced to the 150-person station would be $19M. The cost to go from a 110-person station with no enhancement to a 150-person station would be about $40M. The plan is constructed so as to allow continuation of the science program during construction.

This plan addresses the critical safety and health issues in the first years of the project, which would require 8 years to complete. At completion, this station would support the same level of science conducted at the South Pole in FY 1996.

Smaller stations could still require a substantial number of support personnel. Therefore, the cost-effectiveness of scientific research would decrease unfavorably, disproportionately to the savings. For the 75-person station, for example, the science population would fall by more than 40% under current operational plans.

Given new budget realities of Federal discretionary budgets, the NSTC believes that fresh consideration of the South Pole station plans is called for. The plans will benefit greatly from further cost-benefit analysis that examines the trade-off between the size, lifetime, and capability of the station vs. the anticipated requirements of the science program. It is essential that the cost savings arising from alternative management approaches, remote operation, robotics, and international cost-sharing be explicitly considered. Both scale and schedule should be re-examined as appropriate to possible new budgetary constraints, such as funding the South Pole station construction within the USAP budget.

Nevertheless, some conditions at the present South Pole Station must be dealt with immediately because they involve risks to the health and safety of personnel or endanger the environment. The USAP should give highest priority to prompt remedy of this situation.

D. International Cost Sharing

As described in the previous chapter, international cooperation is extensive throughout the U.S. Antarctic Program and is the norm among Antarctic Treaty nations; the United States has collaborated with most of them. As an example of an in-kind exchange, during the 1995–1996 season Italy provided helicopter support to U.S. scientists in the Transantarctic Mountains in return for U.S. refueling of Italy's coastal station at Terra Nova Bay. Research cooperation includes international planning of projects, collaborative experiments at multiple sites, shared projects at the same site, and coauthorship of research papers, with each nation funding its own researchers.

At the South Pole, where seven foreign governments and three U.S. agencies besides NSF currently support science, the U.S. now funds all (that is, U.S. and non-U.S.) construction, operations, and logistics. The other nations fund their scientists and their research equipment. As a consequence, the U.S. reviews, approves, and coordinates all experiments; manages the support needed for all participants; and maintains safety and environmental standards. This sustains our influential presence at the South Pole, the convergence of territorial claims.

There are many different possible levels of international cooperation. One level is the present situation, described above. Another option would allow access only to U.S. citizens, with the station thus sized and priced smaller. This latter option is unattractive, since it could profoundly alter the nature of scientific collaboration currently enjoyed in Antarctica.

In a third option, the station would be fully international. The U.S. would be a prorated partner with other Treaty nations in designing, building, operating, and managing the station. The scientific program, safety and environmental standards, and facility improvements would require agreement by the participating nations. Each country would provide its own logistics or pay another country or a contractor for logistics. Since the U.S. is the only nation with heavy-lift ski-equipped airplanes (LC-130s), and it has the nearest airport and seaport (McMurdo), international demand for airlifts to the South Pole could compete with U.S. use of these unique assets.

A more moderate option, however, would allow the U.S. to share some costs internationally. The U.S. would design, build, operate, and manage the core facility, but reserve some berthing and science capacity for scientists who are not funded by the U.S. NSF would seek international financial participation in redeveloping and operating the station. The U.S. would provide all operational support on a cost-reimbursable basis: foreign countries would pay their share of construction and operations prorated against the total number of participants (scientists or technicians) and the use of space and energy. The layout could be developed around separate modules for foreign participants or constructed as an integrated facility. While the option would require some degree of consultation with international partners in laying out the science program, NSF would oversee all support activities to assure compatibility with safety and environmental standards. This would largely preserve our level of influence at the South Pole.

The NSF, guided by Presidential Memorandum 6646, has not entered into formal discussions with other nations regarding possible cost-sharing of South Pole station redevelopment. We support the initiation of such discussions, particularly along the lines of the last option discussed. That is, international participation is to be encouraged commensurate with the scientific involvement of other countries, but sufficient U.S. operational control and authority should be maintained to enforce U.S. safety and environmental standards and to reinforce geopolitical objectives with our South Pole presence. This will almost certainly require that the USAP build and operate the core South Pole station infrastructure. The attraction of any of these options, and the concomitant impact on the budget requirements, can be evaluated only after initial timely discussions with potential international partners.

E. Critical Safety and Environmental Projects

Several areas at the South Pole station pose problems for the safety of personnel or the environment. Although safety measures have been taken to mitigate the threats, these areas are in poor condition, and maintenance is increasingly costly. The conditions in three areas warrant immediate action without regard to any replacement of the station. NSF has requested $25M in its FY 1997 budget request for specific improvements to address critical safety and environmental concerns for the heavy equipment maintenance facility ($8M), the power plant ($12.5M), and the fuel storage facilities ($4.5M).

E1. The Maintenance Facility

The garage and shop have deficiencies that risk health and safety and degrade performance. The buildings are undersized, requiring different trades to use the same space concurrently, lowering efficiency. Administrative controls have reduced risk to personnel, but additional measures will be required as the facilities age. Monitoring shows up to a 30% reduction in productivity.

Needs include (1) exhaust ventilation systems capable of lowering hazardous airborne contaminants to acceptable levels; (2) fire suppression systems where fuels, lubricants, and other flammable materials are near ignition sources; and (3) facilities and equipment to work on heavy industrial vehicles and other large items.

E2. Power

The power plant is the life support of the station, providing electricity, heat, and potable water. The current plant operates at capacity, resulting in brown-outs during peak demand. Although emergency power exists, it is for minimal life support only. Given the harsh environment on the polar plateau, where winter temperatures can drop to -120°F, adequate power and backup power are critical. The three current 350kw generators are relatively fuel inefficient, the 20- to 25-year-old power plant structure is overcrowded, and power distribution systems are in need of replacement The conditions and the eight months of isolation argue persuasively for reliable primary and backup power.

E3. Fuel Storage Facilities

Storage for up to 300,000 gallons of fuel is required at the South Pole to sustain the station for the eight months of winter isolation and through a possible emergency disruption to the annual fuel resupply. Fuel is currently stored in fuel bladders, without secondary containment, that risk leakage or spills. In addition to meeting minimum environmental standards, double-walled steel storage tanks will help ensure that the station has the fuel necessary to last through the season and possible emergencies.

Chapter VI
Conclusions and Recommendations

Based on the material developed in the previous five chapters, the NSTC concludes that the U.S. should be in Antarctica because of the unique and significant opportunities it provides for basic and applied research. The U.S. benefits more than any other nation from the Antarctic Treaty arrangements. Our active and influential presence accords the U.S. a decisive role in the Treaty's activities-based decision making process (see Appendix I) and establishes the political and legal standards that make the Treaty effective. Therefore we believe it essential that the United States maintain an active and influential presence in Antarctica (see Appendix II). *Further, the NSTC believes that, at the current level of investment, the USAP is cost effective in advancing American scientific and geopolitical objectives, and from a science perspective, the NSTC supports the continuation of three stations with year-round presence.*

Maintaining an active and influential presence in the hostile Antarctic environment is costly. The science carried out in Antarctica, described earlier in this report, is unique to the special conditions of the region. The present annual investment of $196M sustains a research program of very high quality that is of great interest to a broad scientific community. Furthermore, the research results often imply consequences for human activities that go well beyond those usually associated with fundamental research. The examples cited — the possible collapse of the west Antarctic ice sheet, the circulation of deep ocean currents, and the hole in the ozone layer — have potentially significant consequences for all Earth's inhabitants. Over the past decade, these particular issues have been of increasing interest to policy makers, the general public, and the scientific community, and they account for much of the present attention given to this program. Elements of the biological research in the USAP deal with the possibilities for life forms emerging and surviving under extreme conditions, keys to the very origin of life on Earth and elsewhere. The South Pole's cold, dry atmosphere, its six months of darkness for continuous viewing of the southern sky, and the presence of three kilometers of clear ice have stimulated astronomers and astrophysicists to locate world class observational facilities at the Pole. These experiments help inform us of the vast Universe that lies beyond our reach and define the context of our existence.

American's sense of exploration is satisfied both by the science and by the challenge inherent in work in the largely unknown region of Antarctica and its surrounding oceans. The three research stations, McMurdo, Palmer, and Amundsen-Scott, are strategically located on the Continent and have valid, scientific and operational missions that are vastly different. As shown in Tables IV-1 and IV-2, the balance of resource allocation between research support and operations in the USAP is more favorable than previously recognized. That is, the balance is typical of other large-scale U.S. scientific programs that require expensive platforms for the conduct of their research. When evaluating the investment in the USAP, it must be kept in mind that the Program has been given the responsibility for providing the supporting infrastructure for the entire U.S. program of research in the Antarctic region, south of 60° south latitude.

The possibility of reduced budgets raise issues of priorities, particularly when capital investments such as the renovation of the South Pole Station come to the fore. Priority decisions dealing with the fate of the USAP should reflect its position as a National Program serving scientific, environmental, and geopolitical concerns. If the USAP is to continue its excellent research activity, providing the U.S. with an active and influential presence in the Antarctic, it will have to pursue further efficiencies and cost savings aggressively in response to budgeting constraints.

The NSTC recognizes that maintaining the high scientific value of the program in the face of budgetary uncertainties places a high premium on detailed understanding of options for cost reduction. The report describes anticipated savings from further management efficiencies and program retrenchments, and the scientific losses associated with the latter. A specially constituted external panel, including members from the scientific, technological, and management communities accustomed to operations in challenging environments, should be established. This panel should be free to examine various infrastructure, management, and scientific options, including a reduction in scope commensurate with a range of budgetary scenarios. A several-year freeze in total USAP funding (including South Pole Station construction) is one of the options to be analyzed. Timely input to the budget process, starting with the FY98 budget, is highly desirable. *The NSTC recommends that an external panel be convened by NSF to explore options for sustaining the high level of USAP science activity under realistic constrained funding levels.*

Given the obvious strategic and scientific importance of the South Pole Station, the U.S. should not abandon it. Year-round activity continues to be important. The station is nearing the end of its useful lifetime. The NSF had developed several options for replacing the station that allowed the scientific program to proceed without interruption. However, recently realized fiscal constraints force a re-examination of the size, lifetime, and capability of the Station. The character of the new facility must reflect an anticipated, affordable scientific program at the South Pole in balance with the rest of the USAP's activities. Further, careful note must be taken of new technologies that can provide the needed scientific data in the most cost effective way, including reduced requirements for human presence at the Pole.

International collaboration in research and cooperation in logistics are both attractive and necessary in the Antarctic. As a result, they occur frequently. The internationalization of the construction and subsequent operation of a new South Pole Station raises important issues with regard to the effectiveness of the station management and dilution of the Nation's influential presence at the South Pole. That is, international participation is to be encouraged, commensurate with the scientific involvement of other countries, but sufficient U.S. operational control and authority should be maintained to enforce U.S. safety and environmental standards and to reinforce geopolitical objectives with our South Pole presence. The NSTC supports initiation of discussions with potential international partners.

As a result of the advanced age of the South Pole Station and a heightened awareness of safety and environmental concerns, several matters must be dealt with at the existing station. Among the facilities in need of immediate attention are the vehicle maintenance facility, the power plant and the fuel storage tanks. Major deficiencies at these facilities increase the probability of serious accidents or environmental insults and create additional maintenance costs in the present operating budget. This situation must be remedied as a high priority. *The USAP should give highest priority to correcting critical health, safety, and environmental issues at the current station.*

APPENDIX I

THE ANTARCTIC TREATY AND THE ANTARCTIC TREATY SYSTEM

Background: Antarctica and Antarctic waters were the scene of exploratory and scientific expeditions and commercial whaling and sealing during the nineteenth and first half of the twentieth centuries. By 1941, seven countries had made claims to parts of Antarctica (Argentina, Australia, Chile, France, New Zealand, Norway and UK). The claims of Argentina, Chile and the United Kingdom all overlap in the Antarctic Peninsula and one sector of Antarctica, comprising about 15% of the land area, is unclaimed. Other states active in Antarctica neither assert nor recognize such claims

Following World War II there was an upsurge in research activity in Antarctica culminating in the cooperative scientific program in Antarctica undertaken as part of the International Geophysical Year (IGY) in 1957-58. Twelve States with scientific research and other interests in Antarctica participated in the IGY program. These included the seven claimant States and the United States, Belgium, Japan, South Africa, and the USSR, who made no claims to sovereignty on the continent and did not recognize those of others. The U.S. has the basis for a claim to at least a part of the continent, but has perceived its interests better served by arrangements which assure access to the continent as a whole.

The States active in the IGY devised informal arrangements devised to avoid disruptions resulting from differing territorial claims positions. These worked well and formed the basis of a U.S. initiative to provide a more formal basis for long-term cooperation in Antarctica. This initiative resulted in conclusion of the Antarctic Treaty, signed by these same twelve states in 1959.

The Antarctic Treaty: The Antarctic Treaty, which entered into force in 1961, applies to the area south of 60 degrees south latitude including all ice shelves. The Treaty guarantees freedom of scientific research in Antarctica, placing on a permanent basis the system of peaceful international cooperation which evolved during the International Geophysical Year. It calls for plans for scientific investigations to be shared in advance and the results of scientific investigations to be shared and made freely available.

Equally important, the Treaty establishes Antarctica as a zone of peace reserved exclusively for peaceful purposes. It bans all military activities, including the testing of weapons, and prohibits nuclear explosions and the disposal of radioactive waste. In addition, it provides an absolute right of on-site inspection of all stations and installations in Antarctica to promote the objectives of the Treaty and ensure compliance with its provisions.

To achieve these purposes, the Antarctic Treaty had to deal with the basic legal and political differences over territorial sovereignty in Antarctica. Article IV of the Treaty freezes the question of previously asserted rights and claims to territorial sovereignty in Antarctica, and provides that no acts or activities carried out while the Treaty is in force will constitute a basis for a claim. It also preserves the previously established U.S. basis of a claim. This imaginative formulation permits the parties to agree to disagree over the sovereignty issue and thereby establishes the basis for international cooperation in Antarctica. In effect, for those activities with which it deals, the Treaty provides means for its parties — starting from different legal assumptions — to apply common obligations to activities in Antarctica.

The Antarctic Treaty did not deal with all possible activities in Antarctica. Its substantive provisions, including the juridical accommodation, apply to activities relating to scientific research and the reservation of Antarctica exclusively for peaceful purposes. They do not, for example, extend to resource activities.

At the same time, the Treaty provides a mechanism for dealing with new activities and new circumstances. This mechanism, which is contained in Article IX of the Treaty, provides for meetings of the twelve original contracting parties first within two months of entry into force of the Treaty and at suitable intervals thereafter, for the purpose of exchanging information, consulting together on matters of common interest pertaining to Antarctica and recommending to their governments measures in furtherance of the principles and objectives of the Treaty.

The Treaty also provides that these consultative meetings, as they are now called, are open not only to full participation by representatives of the twelve original contracting parties but also to representatives of any acceding party during such time as that party demonstrates its interest in Antarctica by the conduct of substantial scientific research there. There are now twenty-six Parties (Antarctic Treaty Consultative Parties or ATCPs) with full rights of participation in these meetings. Currently, the ATCPs are Argentina, Australia, Belgium, Brazil, Chile, China, Ecuador, Finland, France, Germany, India, Italy, Japan, Republic of Korea, the Netherlands, New Zealand, Norway, Peru, Poland, Russia (as successor to the USSR), South Africa, Spain, Sweden, the United Kingdom, the U.S. and Uruguay. In addition, representatives of all other parties to the Antarctic Treaty also participate in consultative meetings as observers. There are also sixteen such non-Consultative Parties (NCPs) — Austria, Bulgaria, Canada, Colombia, Cuba, Czechoslovakia, Denmark, Greece, Guatemala, Hungary, the Democratic People's Republic of Korea, Papua-New Guinea, Romania, Switzerland, Turkey and Ukraine.

There have been nineteen Antarctic Treaty Consultative Meetings (ATCMs) since the Antarctic Treaty entered into force, with the next, scheduled for May, 1996 in the Netherlands. As a result of these ATCMs, approximately two hundred agreed recommendations have been adopted by the Consultative Parties.

The Antarctic Treaty System: The agreed recommendations adopted at the ATCMs incorporate a wide range of measures to give effect and elaborate the principles and purposes of the Antarctic Treaty. A significant proportion of these recommendations deal with protection of the Antarctic environment.

Equally important from the environmental perspective, the ATCMs have provided the mechanism for the ATCPs to delineate and respond to the challenge of possible resource activities in Antarctica. Recommendations adopted at ATCMs have included initiatives which have lead to the conclusion of four separate treaties which in whole or in part seek to address resource issues. Two of these are in force. These separate treaties are:

- the Convention on the Conservation of Antarctic Seals; (concluded in 1972, entered into force in 1978);
- the Convention on the Conservation of Antarctic Marine Living Resources (concluded in 1980, entered into force in 1982); and
- the Protocol on Environmental Protection to the Antarctic Treaty (concluded in 1991, not in force).

In addition, the Scientific Committee on Antarctic Research (SCAR), a non-governmental ICSU body, is generally associated with the Antarctic Treaty system. SCAR provides a continuing mechanism for the Antarctic scientific community to identify research priorities in Antarctica and promote cooperative efforts for their achievement. SCAR, which also grew out of the IGY has no formal ties to the Antarctic Treaty, but serves as a source of expert scientific opinion.

The Convention on the Conservation of Antarctic Seals (CCAS): The Antarctic Seals Convention establishes limitations upon, and provides a mechanism to deal with, commercial sealing in Antarctica. It was negotiated primarily as a precautionary measure in light of concern over the possible re-initiation of pelagic commercial sealing in Antarctica. Interest in such sealing has not materialized as was confirmed at the meeting of Parties to CCAS in September, 1988.

The Convention on the Conservation of Antarctic Marine Living Resources: The Convention on the Conservation of Antarctic Marine Living Resource (CCAMLR) resulted from an initiative taken at ATCM IX in London in 1977. The Convention represents a precedent-setting effort to develop and apply an ecosystem-wide management approach to the waters surrounding Antarctica. Its objective is to ensure that any harvesting of Antarctic marine living resources is consistent not only with the health of target populations but also with that of dependent and related species and with maintenance of ecological relationships.

Consistent with its conservation objectives, the Convention applies to a geographic area defined to approximate the full extent of the Antarctic marine ecosystem. This area, defined by specific coordinates, extends to those waters found south of the Antarctic Convergence, or polar front, which is the transition zone between Antarctic waters to the south and warmer sub-Antarctic waters to the north. It should be noted that the Convention area is considerably larger than that covered by the Antarctic Treaty (which applies to the area south of 60° South Latitude).

The Convention establishes the Commission for the Conservation of Antarctic Mineral Living Resources, headquartered in Hobart, Tasmania; the Scientific Committee for the

Conservation of Antarctic Marine Living Resources, charged with providing objective scientific assessments and recommendations to the Commission; and a secretariat to serve both the Commission and Scientific Committee. The Convention provides that the Commission will operate on the basis of a consensus — or no-objection — procedure which has been characteristic of the Antarctic Treaty system.

There are now 28 Parties to CCAMLR, of whom 21 are members of the Commission. Its eleventh annual meeting will take place in November, 1993. Since the entry into force of CCAMLR in 1982, there has been steady progress in the development of the scientific and data bases for Population assessments, on the delineation and implementation of conservation measures, particularly those aimed at restoration of fishery stocks depleted during the 1970s and in elaborating a system of observation and inspection. Concerted action by Parties to CCAMLR will continue to be necessary to achieve its conservation objectives.

The Protocol on Environmental Protection to the Antarctic Treaty: The Protocol was concluded in Madrid on October 4, 1991. It builds upon the Antarctic Treaty to extend and improve the Treaty's effectiveness as a mechanism for ensuring the protection of the Antarctic environment. It designates Antarctica as a natural reserve, devoted to peace and science, and sets forth legally binding environmental protection principles applicable to human activities in Antarctica, including obligations to accord priority to scientific research.

The protocol prohibits all activities relating to Antarctic mineral resources, except for scientific research, and provides that this prohibition cannot be amended by less than unanimous agreement for at least 50 years following entry into force of the Protocol.

The Protocol requires Parties to protect Antarctic fauna and flora and imposes strict limitation on disposal of wastes in Antarctica and discharge of pollutants into Antarctic waters. It also requires application of environmental impact assessment procedures to activities undertaken in Antarctica, including non-governmental activities, for which advance notice is required under the Antarctic Treaty. Parties are further required to provide for response to environmental emergencies, including the development of joint contingency plans.

Detailed mandatory rules for environmental protection pursuant to these requirements are incorporated in a system of annexes, forming an integral part of the Protocol. Specific annexes on environmental impact assessment; conservation of Antarctic fauna and flora; waste disposal and waste management; and the prevention of marine pollution were adopted with the Protocol. A fifth annex on area protection and management was adopted October 17, 1991 by the Antarctic Treaty Consultative Parties at the Sixteenth Antarctic Treaty Consultative Meeting. Provision is also made for additional annexes to be incorporated following entry into force of the Protocol.

Dispute settlement procedures are included in the Protocol. These Include compulsory and binding procedures for disputes over the interpretation or application of, and compliance with, the provisions of the Protocol relating to mineral resource activities, environmental impact assessment and response action, as well as most provisions included in the Annexes.

The Protocol establishes a Committee on Environment Protection, as an expert advisory body to provide advice and formulate recommendations to the Antarctic Treaty Consultative Meetings in connection with the implementation of the Protocol.

Conclusion of the Protocol resulted from negotiations during the Eleventh Antarctic Treaty Special Consultative Meeting among the Antarctic Treaty Consultative Parties - Argentina, Australia, Belgium, Brazil, Chile, China, Ecuador, Finland, France, Germany, India, Italy, Japan, Republic of Korea, Netherlands, New Zealand, Norway, Peru, Poland, South Africa, Spain, Sweden, the Soviet Union, the United Kingdom, the United States and Uruguay.

Fourteen Contracting Parties which are not Consultative Parties - Austria, Bulgaria, Canada, Colombia, Czechoslovakia, Cuba, Denmark, Greece, Guatemala, Hungary, Democratic People's Republic of Korea, Papua New Guinea, Romania and Switzerland, as well as representatives of a number of international organizations, attended as observers.

The Special Consultative Meeting, convened pursuant to a recommendation adopted in Paris in October, 1989, had as general terms of reference the "further elaboration, maintenance and effective implementation of a comprehensive system for the protection of the Antarctic environment." The first session of the Special Consultative Meeting took place in Vina del Mar, Chile, November 19-December 6, 1990; and the second in Madrid, April 22-30, June 17-22, and October 3-4, 1991.

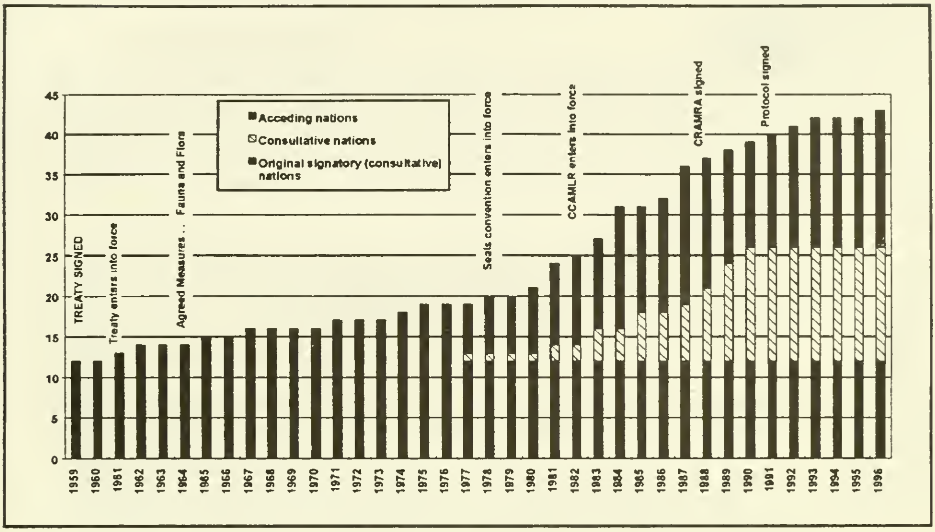
The Protocol, including the annexes on environmental impact assessment, conservation of Antarctic fauna and flora, waste disposal and waste management, and prevention of marine pollution, was adopted by consensus of the twenty-six Antarctic Treaty Consultative Parties. The Protocol was opened for signature on October 4 in Madrid and, thereafter, in Washington until October 3, 1992. All 26 of the Antarctic Treaty Consultative Parties, including the United States, signed the Protocol during that period, along with ten of the Contracting Parties that are not Consultative Parties.

The Protocol and Annexes I through IV will enter into force on the thirtieth day following the date on which all 26 Antarctic Treaty Consultative Parties have deposited their instruments of ratification, acceptance, approval or accession. Annex V on Area Protection and Management will enter into force on the date on which that Annex has been approved by all Antarctic Treaty Consultative Parties, provided that the Protocol has entered into force.

As of March 1, 1996, twenty of the ATCPs had ratified the Protocol: Argentine, Australia, Brazil, Chile, China, Ecuador, France, Germany, Italy, Korea, Netherlands, Norway, Peru, Poland, Spain, Sweden, United Kingdom and Uruguay. For the United States, the Senate has given its advice and consent to ratification. However, implementing legislation also necessary for ratification has not yet been enacted by the Congress. Such legislation has been introduced.

See attached bar graph, "Number of Antarctic Treaty Nations, 1959-1996"

Table AI-1. Number of Antarctic Treaty nations, 1959-1996



United States Department of State

Washington, D.C. 20520

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March 9, 1996

UNCLASSIFIED

MEMORANDUM FOR ANDREW D. SENS
EXECUTIVE SECRETARY
NATIONAL SECURITY COUNCIL

SUBJECT: Antarctica: Funding of the United States Antarctic Program, including South Pole Station

The United States has important foreign policy and national security interests in Antarctica. These interests are given concrete expression through the Antarctic Treaty of 1959. The Treaty guarantees freedom of scientific research in Antarctica and prohibits military and nuclear activities, with rights of on site inspection to assure compliance. It is the indispensable basis for successful pursuit by the United States of the unique opportunities Antarctica offers for scientific research, as well as associated goals of protecting the environment of Antarctica and conserving its resources.

The Treaty's framework for managing conflicts over territorial sovereignty in Antarctica has prevented regional conflicts such as the dispute over the Beagle Channel or the Falklands War from spreading to Antarctica. The international peace and political stability in the area resulting from the Treaty has greatly supported foreign and national policy objectives of the United States. Moreover, the importance of Antarctica for national security, environmental and scientific interests was reflected in PDD-26 signed by President Clinton.

The success of the Antarctic Treaty and the achievement of United States interests through it rest upon the year round presence in Antarctica maintained by the United States Antarctic Program (USAP), the program of scientific research and associated logistics funded and managed by the National Science Foundation. The most visible symbol of this presence is South Pole Station, in continuous operation since 1956.

UNCLASSIFIED

Budget constraints have raised important issues relating to United States presence in Antarctica. The Senate Appropriations Committee has expressed concern over the costs of the USAP and called for the National Science and Technology Council to review United States presence in Antarctica. U.S. facilities at the South Pole have reached the end of their design life and need replacement.

The Department believes that our foreign policy and national interests must be reflected in budgetary decisions affecting United States presence in Antarctica. This presence is particularly important when viewed in the light of the dispute over territorial sovereignty in Antarctica. Seven nations (Argentina, Australia, Chile, France, New Zealand, Norway and the U.K.) assert claims to territorial sovereignty over parts of Antarctica. The claims of Argentina, Chile and the U.K. overlap. The United States, along with Russia and others active in Antarctica, reject claims and assert the right of access to all areas of Antarctica for peaceful purposes. At the same time, the United States has a solid basis of claim in Antarctica, resulting from its activities there prior to 1959.

The Antarctic Treaty includes imaginative juridical and decisionmaking provisions that permit Parties to agree to disagree over sovereignty. It freezes previously asserted rights and claims to territorial sovereignty in Antarctica, including reservation of any prior basis of claim (e.g., the United States basis of claim). It prohibits new claims and provides that no acts or activities carried out while the Treaty is in force may constitute a basis for a claim. Decisionmaking authority in the Treaty system is linked to actual involvement in activities in Antarctica. The twelve nations that negotiated the Treaty were all active in scientific research on the continent. Participation in decisionmaking by nations that subsequently become Party requires demonstration of interest in Antarctica by the conduct of substantial scientific research there.

The Treaty has proven to be durable and dynamic, evolving to deal effectively with new scientific, environmental and resource management issues and to accommodate new participants. The number of Treaty Parties active in Antarctica has grown from the original twelve to twenty-six and includes all permanent members of the United Nations Security Council as well as Japan, India and Brazil. The regular meetings of the Treaty Parties provide a forum for peaceful cooperation among them even when bilateral relations are strained or hostile. For example, Argentina and the U.K. continued to interact peacefully within this forum during the Falklands War and the United States and Soviet Union were able to cooperate on Antarctic matters even when relations were at their worst.

More than any other nation, the United States benefits from the Antarctic Treaty. The potential for international discord and conflict over Antarctica that would exist absent the Treaty is, if anything, greater now than when it was negotiated. The United States has developed a world class program of scientific research in Antarctica and shaped the innovative resource management arrangements that have evolved under the Treaty. The effective operation of the Antarctic Treaty is a direct result of the active and influential United States presence in Antarctica maintained through the Antarctic Program. This presence accords the United States a decisive role in the Treaty's activities based decision system and in maintaining the political and legal balance that makes the Treaty work.

The Department of State believes it essential that the United States continue to maintain an active and influential presence in Antarctica, including year-round operation of South Pole Station. United States presence at the South Pole Station demonstrates United States commitment to assert its rights in Antarctica, its basis of claim, and its committment to conduct cutting edge scientific research there. Abandonment of the Station would create a vacuum and likely result in a scramble to occupy the site, to the detriment of our position as well as to the stability of the Treaty system.

Shrinking budgets raise issues of priority, particularly in respect of capital outlays such as are projected for necessary replacement of South Pole Station. However, funding decisions on the United States Antarctic Program must be based on the fact that it is a national program that serves important foreign policy and national objectives as well as basic scientific, environmental and economic interests. From this perspective, appropriation of the funds necessary to maintain an active and influential United States presence in Antarctica, including renovation of South Pole Station, represents both a priority and cost effective investment.

The Department of Defense has cleared this memorandum.

William J. Burns fr
Executive Secretary

APPENDIX III

Institutions receiving awards from the U.S. Antarctic Program

ALABAMA

University of Alabama at Tuscaloosa

ALASKA

University of Alaska at Fairbanks

ARIZONA

University of Arizona
Northern Arizona University

ARKANSAS

University of Arkansas

CALIFORNIA

University of San Francisco
Point Reyes Bird Observatory
California Institution of Technology
University of California at Santa Barbara
University of California at Berkeley
University of California at San Diego, Scripps Institution
University of California at Davis
Naval Postgraduate School
Stanford University
Lockheed-Martin Advanced Technology Center

COLORADO

University of Colorado at Boulder
Colorado State University
University of Denver

CONNECTICUT

University of Connecticut

DELAWARE

University of Delaware
Bartol Research Laboratory

DISTRICT OF COLUMBIA

National Academy of Sciences
Library of Congress

FLORIDA

Embry Riddle Aeronautical University
Florida State University
University of Miami – Rosenstiel School
of Marine and Atmospheric Science
University of South Florida

GEORGIA

Skidaway Institute of Oceanography

HAWAII

University of Hawaii

IDAHO

Idaho National Engineering Laboratory

ILLINOIS

Augustana College
University of Chicago
Northern Illinois University
University of Illinois

INDIANA

Indiana University
Purdue University

KANSAS

University of Kansas

LOUISIANA

LUMCON - Louisiana Universities Marine Consortium
Louisiana State University

MASSACHUSETTS

Woods Hole Oceanographic Institution
Massachusetts Institute of Technology
University of Massachusetts, Dartmouth
University of Massachusetts, Amherst
Northeastern University

MARYLAND

Capital Systems Group Incorporation
National Aeronautics Space Adminstration-Goddard Space Flight Center
University of Maryland
Johns Hopkins University

MAINE

University of Maine

MICHIGAN

University of Michigan

MISSOURI

Washington University

MINNESOTA

St. Olaf College
University of Minnesota at Twin Cities
Augsburg College

MISSISSIPPI

University of Southern Mississippi

MONTANA
Montana State University

NEBRASKA

University of Nebraska

NEVADA

University of Nevada Desert Research Institute
University Nevada Las Vegas

NEW HAMPSHIRE

USACRREL: Department of Army Cold Regions Research
and Engineering Laboratory
University of New Hampshire
Dartmouth College

NEW MEXICO

New Mexico Institute of Mining and Technology

NEW YORK

Hamilton College
Columbia University
Clarkson University
SUNY at Stony Brook
State College at Geneseo

NORTH CAROLINA

Duke University

OHIO

Ohio State University Research Foundation
Kent State University
Case Western Reserve University

OREGON

University of Oregon
Oregon State University

PENNSYLVANIA

Pennsylvania State University at University Park

RHODE ISLAND

Brown University
University of Rhode Island

SOUTH CAROLINA

College of Charleston

TENNESSEE

University of Tennessee at Knoxville
Vanderbilt University of Memphis

TEXAS

Texas A&M University Research Foundation
University of Texas at Austin
Southern Methodist University
Rice University
University of Houston

UTAH

University of Utah

VIRGINIA

Virginia Institute of Marine Science (William & Mary)
Blue Pencil Group Incorporation
Old Dominion University

WASHINGTON

Washington State University
University of Washington
McPhee Research
SAIC

WEST VIRGINIA

West Virginia University

WISCONSIN

University of Wisconsin at Oshkosh
University of Wisconsin at Madison
University of Wisconsin at Milwaukee

WYOMING

University of Wyoming

APPENDIX IV

President's memorandum regarding Antarctica

Memorandum 6646 February 5, 1982

THE WHITE HOUSE
WASHINGTON

MEMORANDUM FOR THE SECRETARY OF STATE
THE SECRETARY OF THE TREASURY
THE SECRETARY OF DEFENSE
THE SECRETARY OF THE INTERIOR
THE SECRETARY OF COMMERCE
THE SECRETARY OF TRANSPORTATION
THE SECRETARY OF ENERGY
THE DIRECTOR, OFFICE OF MANAGEMENT AND BUDGET
THE DIRECTOR OF CENTRAL INTELLIGENCE
CHAIRMAN, JOINT CHIEFS OF STAFF
DIRECTOR, ARMS CONTROL AND DISARMAMENT AGENCY
DIRECTOR, OFFICE OF SCIENCE AND TECHNOLOGY POLICY
ADMINISTRATOR, ENVIRONMENTAL PROTECTION AGENCY
DIRECTOR, NATIONAL SCIENCE FOUNDATION

SUBJECT: United States Antarctic Policy and Programs

I have reviewed the Antarctic Policy Group's study of United States interests in Antarctica and related policy and program considerations, as forwarded by the Department of State on November 13, 1981, and have decided that:

- The United States Antarctic Program shall be maintained at a level providing an active and influential presence in Antarctica designed to support the range of U.S. Antarctic interests.
- This presence shall include the conduct of scientific activities in major disciplines; year-round occupation of the South Pole and two coastal stations; and availability of related necessary logistics support.
- Every effort shall be made to manage the program in a manner that maximizes cost effectiveness and return on investment.

I have also decided that the National Science Foundation shall continue to:

- budget for and manage the entire United States national program in Antarctica, including logistic support activities so that the program may be managed as a single package;
- fund university research and federal agency programs related to Antarctica;
- draw upon logistic support capabilities of government agencies on a cost reimbursable basis; and
- use commercial support and management facilities where these are determined to be cost effective and will not, in the view of the Group, be detrimental to the national interest.

Other agencies may, however, fund and undertake directed short-term programs of scientific activity related to Antarctica upon the recommendation of the Antarctic Policy Group and subject to the budgetary review process. Such activities shall be coordinated within the framework of the National Science Foundation logistics support.

The expenditures and commitment of resource necessary to maintain an active and influential presence in Antarctica, including the scientific activities and stations in the Antarctic, shall be reviewed and determined as part of the normal budget process. To ensure that the United States Antarctic Program is not funded at the expense of other National Science Foundation programs, the OMB will provide specific budgetary guidance for the Antarctic program.

To ensure that the United States has the necessary flexibility and operational reach in the area, the Departments of Defense and Transportation shall continue to provide, on a reimbursable basis, the logistic support requested by the National Science Foundation and to develop, in collaboration with the Foundation, logistic arrangements and cost structure required for effective and responsive program support at minimum cost.

With respect to the upcoming negotiations on a regime covering Antarctic mineral resources, the Antarctic Policy Group shall prepare a detailed U.S. position and instructions. These should be forwarded for my consideration by May 15, 1982.

Ronald Reagan

APPENDIX V

Statement on the U.S. Antarctic Program adopted by the National Science Board at its 331st meeting, August 18, 1995

The history of Antarctic exploration and research is extraordinary, dramatically demonstrated by major commitments to science for over the past forty years. Antarctica provides unique sites for many areas of astronomy, astrophysics, terrestrial climate, geophysical, and oceanographic research. These remarkable features have been and continue to b the central rationale for the establishment of and continued investments in a focused and organized program of research in this region. The productivity and world-class results of these investments in scientific research in Antarctica are well-vested in new and fundamental scientific knowledge and expanded understandings of the southern polar regions.

Reflecting the importance of the South Pole for scientific research as well as supporting the Antarctic Treaty, long a cornerstone of U.S. policy, the National Science Foundation has been and continues to be charged with the responsibility of managing the United States Antarctic Program.

Since the inception of the U.S. Antarctic Program, the Department of Defense has provided all major logistics support. In particular, the airlift support has been the essential support component. The air logistics capabilities of DoD remain critical to the continued existence of the U.S. Antarctic Program.

Recognizing the continuing national and international importance of the U.S. Antarctic Program, and the critical role DoD plays in support of that Program, the National Science Board,

RESOLVES, and strongly recommends that:

> NSF maintain all appropriate logistical capabilities to support the U.S. Antarctic Program, including necessary support from DoD to sustain an active U.S. presence in the Antarctic.
>
> RECOMMENDATION
>
> > RESOLVED, that the National Science Board approve the inclusion of construction funding of the 110-person expandable South Pole Redevelopment Project in an amount not to exceed $181 million, in the National Science Foundation's FY97 Budget Request, above the OMB guidance level, and authorizes the Director negotiate with OMB the overall funding for this project.

FOLLOW-UP TO THE JULY 23 HEARING ON THE FUTURE OF ANTARCTIC RESEARCH

David Clark, chairman, Polar Research Board
Robert Rutford, U.S. Delegate to SCAR and former chairman, Polar Research Board

1. What priority would you assign to rebuilding the South Pole station within the context of a fixed budget for the U.S. Antarctic Program?

> The National Science Foundation is the federal agency charged with carrying out the U.S. national policy and program in the Antarctic. The South Pole Station is a key part of the U.S. national program because of its strategic location for the conduct of science and for the implementation of the stated U.S. policy in Antarctica. Given the endorsement by the NSTC report for the operation of all three existing stations in Antarctica, the rebuilding of South Pole Station is a very high priority. This is a decision that has been well studied. The National Science Board examined the request to rebuild the station and came to a positive decision. They then asked an outside committee chaired by Dr. Guy Stever to look at their decision, and that committee also came to the conclusion that the station should be rebuilt. There is wide consensus in the polar community, including among the members of the Polar Research Board, that the station is important and that rebuilding is a high priority.

2. Assuming fixed budgets, if savings cannot be found in the current program of a magnitude needed to rebuild the South Pole Station, can the funds be taken from operations, logistics and project support? Is this a feasible option? What would be the temporary and the permanent effects on Antarctic research activities if support for operations and research projects were reduced for five years or so to fund rebuilding the South Pole Station?

> The current Antarctic program consists of science, science support (project support), and logistics support. If the funds to rebuild South Pole Station must come solely from within Antarctic budget, then difficult decisions regarding all areas of support will be required. If one area is cut it will certainly affect other areas. For example, if a ship were left unused for a year it would have an impact on the science budget. If the science programs were reduced there would be a decrease in the science support requirements in the field.
>
> A 5-year period of reduction in science funding would be devastating and the quality of the research would suffer. While it might be possible to reduce the level of funding for one or possibly two years without a major negative impact, if the funding were reduced for a longer period there would be

critical implications. For instance, good scientists would quickly leave the Antarctic program. They would reorient their research and seek funds in more promising areas. Research activities and graduate student support are not easily turned on and off, so a 5-year slow-down would quickly drive people away and irreversibly break the continuity of critical long-term activities. It would be difficult to reestablish the Antarctic program at the same level of excellence.

3. Do you believe that the Antarctic research community would support diverting funds from operations, logistics and research project support to rebuilding the South Pole station if no other budget alternative is feasible?

It is likely that the community would support the diversion of some funds to assist with the construction of a new South Pole station. However, it is not likely that the research community would support the diversion of all of the funds necessary for this major construction project. There are a number of disciplines active in Antarctic research that make no use of the South Pole Station, and this community would react most if the diversion of funds lasted for a 5-year period.

It is our understanding that the NSF is considering internal budget adjustments within the Office of Polar Programs to provide $10 million and that an additional $15 million has been made available by OMB to provide the $25 million identified by the NSTC report as needed to correct "critical health, safety, and environmental issues at the current station." Funding at this level and from these sources would allow a continued level of quality research activity while the 110-person new South Pole Station is being constructed.

4. Under this fixed-budget scenario, should the size of the rebuilt South Pole Station be scaled back to reduce construction and operations costs? What research opportunities would be lost with a station smaller than the one which is now being proposed?

The size of the station has been thoroughly studied by several groups. The present users of the station, OPP staff, committees of the National Science Board, and the Stever committee have all considered the size of the station during their deliberations. The augmented 110 person station seems to be the appropriate size to support present and future research activities at the South Pole.

Observational sciences require long-term studies to have any real value. This means that many of the science programs at the South Pole will have a fairly long life. Thus, the ability to add new studies as they become necessary will require a station that can accommodate existing programs and have some flexibility to incorporate new ones. A smaller station would lack this flexibility to adjust to new priorities, with the result that new science will be delayed by space constraints, perhaps for years until space becomes available as current projects come to an end.

Just what research opportunities would be lost with a smaller station is a question that cannot be answered in any detail. As former PRB chairman Dr. Robert Rutford indicated in his oral testimony, it is impossible to predict what science will be done at the South Pole over the next several decades and, therefore, to predict what science opportunities would be lost if the station was not rebuilt as planned.

5. The NSTC report suggests the exploration of greater international cost-sharing for Antarctic research and support activities as a potential source of economies that could provide funding for the South Pole station replacement. Do you believe that significantly greater sharing of resources among the national programs in Antarctica is possible and desirable?

We have just returned from a meeting of the Scientific Committee on Antarctic Research in Cambridge, England. All of the nations with Antarctic research programs were at that meeting, represented by scientists and the operators of national Antarctic programs. The amount of international collaboration in science, the sharing of logistic resources, and the recognition that joint projects between nations are necessary in the current budget climate was the subject of much discussion and planning.

The Office of Polar Programs can tell you in detail of the many international collaborations that the United States is currently involved in. These range from activities such as the drilling at Cape Roberts involving five countries to bi-lateral agreements with France, South Africa, Italy. Even though many such collaborations are occurring, there certainly is opportunity for more. However, the degree of international collaboration is, perhaps, under-estimated by some, and you might wish to have OPP give a detailed briefing on the existing involvement with other countries.

It is unlikely that the cost-sharing scenarios outlined in the NSTC report would have a major impact on the costs of constructing and operating South Pole Station. The basic infrastructure costs are high, and the costs of conducting research are relatively small add-ons to the basic station costs.

6. Do you agree with the finding of the NSTC report that the U.S. should continue to operate three permanent Antarctic stations, even under a fixed-budget scenario?

Yes, the three stations currently operated have very different roles to play in the U.S. research strategy. The Palmer Station provides a base for marine biology of all types, it is in a climatic zone that allows year-round access, and it is strategically located in an area of disputed claims. The McMurdo Station is the farthest point south on the Antarctic continent that is accessible for ships to carry in supplies. McMurdo is the base for most inland field party activity, it is a supply point for South Pole Station, and it offers a critical sea-ice runway for the start of the season. McMurdo has a long history of observations regarding weather, upper atmosphere studies, etc. It has served and continues to serve as a key base for studies of seals, penguins, and other marine species.

South Pole Station is strategically located and provides a base for science that is high, dry, and specialized. There is no other station like it in Antarctica. It has a long observational record, is a critical site in observing changes in ozone, and is the base for unique astronomy projects that are providing new insights into astro-physics research. The Polar Research Board agrees that the three stations should remain open.

7. The U.S. supports research programs focused in both polar regions. In the Antarctic, NSF oversees the U.S. logistics and support activities and funds most research projects. In the Arctic, NSF is just one of the agencies funding research projects, along with DOD, Interior, NASA, and logistics and support activities are not separately funded and managed by a single agency (people live in Arctic regions and private sector support services may be procured as part of the funds provided to and individual research projects). Total federal R&D funding for Antarctic activities, a figure approaching $200 million per year, is roughly equivalent to funding for Arctic activities.

7a. Is there overlap between Antarctic and Arctic research activities?

Polar research involves activities unique to high latitudes, and because both north polar and south polar locations involve extremes of solar seasonality including the presence of ice and snow, there are commonalities and also sometimes overlap. However, the overlap is less than what is suggested by the similarities of climate. In fact, the polar overlap is much less than the overlap that exists in a number of other research ventures such as medicine, physical chemistry, or plasma physics. The differences between the two polar areas gives rise to research priorities that are quite different. The Arctic region is principally an ocean surrounded by land, while the Antarctic area is principally land surrounded by an ocean. This results in different problems and different research techniques. For example, astronomical research in the Antarctic involves studies unique to the stable high latitude (and altitude) position that permits observation of celestial events from a more or less uniform distance and through a very transparent atmosphere. Arctic astronomy is more difficult because the ocean and its frozen surface do not permit a stable platform nor a water and aerosol free atmosphere. Magnetic lines of force move in opposite directions at the north pole and the south pole and this produces significantly different kinds of astrophysical activities.

Similarly, geological and geophysical research in the two polar areas involves different problems, techniques, and solutions. While geological and geophysical work in the Antarctic may include work on crustal exposures that can be studied much as they are in other parts of Earth, the ice cover, in many places hundreds of kilometers thick, obscures much of the Antarctic's geologic structure. This means that most of Antarctica can only be studied by indirect geophysical methods. However, the thick ice-cover produces continental glaciers that are studied with unique objectives that have great differences from studies in most parts of the Arctic (with the exception of Greenland).

In contrast to Antarctic work, geological and geophysical work in much of the Arctic involves study of Earth structures beneath 3000-4000m of water with a frozen surface. Direct observations include recovery of sediment cores from the ocean floor and underwater photography, while geophysical measurements are made from aerial, surface, and submarine activities. The research methodology contrasts with geological and geophysical work in the Antarctic.

Differences in Antarctic and Arctic flora and fauna require quite different techniques with different objectives and results. The differences in bipolar research are equally profound for most other things, e.g. there is no "Arctic haze" in the Antarctic, humans are more affected by the ozone hole in the Arctic than the Antarctic because more people live in the Arctic, Arctic weather patterns affect mostly northern hemisphere climate, but the formation of Antarctic deep water is important for all Earth's oceans (and Earth climate). In most areas of research, Arctic and Antarctic activities have differences that are much more significant than their areas of overlap.

7b. Does the current funding balance between Antarctic and Arctic research activities reflect appropriate priorities in terms of research opportunities available in each region and important national goals and interest? Do more important research opportunities exist in one region than the other, and are these opportunities being pursued?

According to the figures furnished by the government, the dollars spent in both regions is approximately the same. However, this does not mean that the research in the two areas is necessarily of the same magnitude. Perhaps the most important difference is that all U.S. research activity in the Antarctic is centered in the National Science Foundation (NSF), specifically the Office of Polar Programs (OPP), and this single office coordinates the U.S. priorities and funding with at least some attention to internationally coordinated Antarctic activities articulated by Scientific Committee on Antarctic Research (SCAR) and the Council of Managers of National Antarctic Programs (COMNAP). In contrast, priorities and funding for the Arctic are spread through a number of different government agencies, each of which has different interests, expertise, and budget priorities. In spite of attempts to correlate Arctic research programs, the diffusion of interests and funding among different groups results in minimal coordination. In addition, the U.S. Arctic research community has not yet defined what kind of role the relatively young International Arctic Science Committee (IASC) will have in U.S. Arctic priorities, if at all. The absence of a central coordinating body for Arctic research continues to be a problem. For example, certain parts of the Arctic research community were dependent on the EPA monitoring of a number of Arctic environmental parameters. Without consultation with many of the Arctic scientists for whom the data-gathering was important, the Arctic EPA program was terminated. While there also are examples of coordination (e.g., the NSF Surface Heat Budget of the Arctic (SHEBA) project and the DOE Arctic heat monitoring project), the same degree of correlation and coordination that the NSF provides for the Antarctic is not available in the Arctic. While the international political considerations that are critical in the Antarctic are at least partly responsible for this greater U.S. concern, this should be balanced by the fact that there are U.S. citizens who are permanent residents of the Arctic.

The research opportunities and needs in the two polar areas are quite different, as referred to in question 7a. Of course, different kinds of research are important in the two areas. For example, astronomical research may be more important in the Antarctic than the Arctic, but marine geological research will make a greater contribution to the knowledge of the Arctic than similar research will produce in the Antarctic. However, for the first time during the past few years, research opportunities in the two areas have been approaching a parity of sorts that was not the case even 5 years ago. The slow progress toward a more ideal research situation is in part because of the absence of a logistical infrastructure and in part the result of the absence of meaningful coordination of activities among the different agencies that support research in the Arctic.

9. Describe the adequacy of logistics support for research in the Arctic; are there outstanding deficiencies that need to be addressed? Is greater coordination for logistics support activities needed among the agencies supporting research in the Arctic?

Logistical support for Arctic research is inadequate. The United States maintains no permanent terrestrial research observatory in the high Arctic (as it does in the Antarctic), and there is no dedicated research vessel for Arctic Ocean work (as there is in the Antarctic). The demise of the Arctic Research Vessel (ARV) initiative is a serious deterrent to Arctic marine science, and because most of the Arctic is marine this can only be considered an extremely serious deficiency for Arctic research. There is little confidence among the Arctic research community that the Coast Guard ship under construction can or will fill the needs of Arctic Ocean research. The importance of Arctic research for the United States suggests that both a terrestrial and marine Arctic logistical infrastructure is necessary. While Coast Guard support of limited and short term Arctic science objectives has been helpful and is greatly appreciated by the Arctic research community, science objectives have always been of secondary importance to the Coast Guard. This is frustrating to a growing number of scientists whose research has not achieved its potential because of limited logistical support. Certainly, greater coordination among the agencies supporting research in the Arctic would be helpful. A charge to some agency to furnish the logistical support for the Arctic similar to that given to the NSF for Antarctic logistical support would be a major step toward correcting this problem. Although this would be a difficult task at a time of budget constraints, Arctic research will lag until this or something similar is accomplished.

QUESTIONS FOR THE RECORD

1. The NSTC report indicates the need to find economics in the U.S. Antarctic Program that, presumably, would be used to fund rebuilding the South Pole Station. Were estimates made of the magnitude of potential savings that can be achieved in the program? Is it feasible to fund rebuilding the South Pole Station from savings in the current program alone?

NSF is developing and refining estimates of the potential cost and benefits, and these will be discussed with an external panel NSF is convening as recommended in the NSTC report. The panel, chaired by Norman Augustine, had its first meeting October 11-12, 1996, and we hope to have their recommendations in early 1997. At the present time, NSF believes it would be very difficult to accommodate the current South Pole Redevelopment Plan (SPRP), which has evolved over time, within the current USAP funding level and budgetary guidance without adversely impacting the current research program.

Nevertheless, the panel is examining options for new ways of doing business in the Antarctic with the following objectives in mind: maintain an active and influential presence in Antarctic; maintain high quality research and education; and provide sound environmental, safety, and health stewardship for all the U.S. activities on the continent. At least one of these options will examine how to accommodate the SPRP and other needed infrastructure needs in a budget that is assumed to remain essentially level for the foreseeable future. Thus, the panel will be looking at a variety of ways to implement both the USAP, the SPRP, and other needs by focusing on such issues as more efficient use of existing infrastructure, adoption of advanced technologies that could potentially reduce costs, strengthen priority setting for research activities, opportunities for increased remote operations, etc. The panel is also expected to consider a variety of metrics NSF can use to monitor the program's performance with respect to research, logistics, and infrastructure development, maintenance, and operations. We will know more about potential savings, programmatic impacts, and options once the panel has reported its findings early next year.

2. Assuming a fixed budget, if savings cannot be found in the current program of a magnitude needed to rebuild the South Pole Station, the funds will need to be taken from operations, logistics, and research project support. Is this a feasible option? What would be the temporary, and the permanent, effects on Antarctic research activities if support for operations and research projects were reduced for five years or so to fund rebuilding the South Pole Station.

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3. If savings from the current program are insufficient, and if it is not feasible to cut the operations, logistics, and research project support substantially, what other options are available for funding the rebuilding of the South Pole Station?

NSF is developing and refining estimates of the potential cost and benefits, and these will be discussed with an external panel NSF is convening as recommended in the NSTC report. The panel, chaired by Norman Augustine, had its first meeting October 11-12, 1996, and we hope to have their recommendations in early 1997. At the present time, NSF believes it would be very difficult to accommodate the current South Pole Redevelopment Plan (SPRP), which has evolved over time, within the current USAP funding level and budgetary guidance without adversely impacting the current research program.

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4. The most recent National Science Foundation Inspector General(IG) report recommends a limit on the amount the Office of Polar Programs can pay in bonuses.

According to the IG, the estimate will save NSF $1 million over five years. What is the status of this recommendation?

Bonuses are part of our contractor's total compensation package that takes into account the ability to recruit quality full-time personnel, to retain valued employees, and to compensate for a longer work-week in Antarctica. The additional pay is based in part on the fact that employees who work in Antarctica have a standard work-week of 54 hours, over 25% more than the 40-hour work week at the contractor's headquarters.

NSF is reviewing the entire contractor's compensation package to determine whether that package needs to be modified to meet the goals of attracting and retaining critically skilled people for the USAP. We must balance the need to provide compensation to affect recruiting and retention goals with the need to keep down program costs. NSF is in the process now of obtaining information pertaining to overall compensation offered by the contractor to its employees.

5. The IG report estimates a potential savings of $4 million dollars by using vacant buildings to house contract employees and military support personnel in New Zealand. The report states NSF is currently conducting this cost analysis. What are the results of this recommendation?

When the OIG made its recommendations concerning the remodeling of old, vacant Navy barracks in Christchurch, New Zealand, to house USAP personnel, the recommendations reflected operations in the U.S. Antarctic Program as of 1994, at the time of the IG visit to Christchurch. At that time, the Navy was providing all LC-130 support operations for the USAP and maintained approximately 110 personnel in Christchurch throughout the Antarctic operating season. This situation -- coupled with the need to house USAP personnel who passed through Christchurch to and from Antarctica -- suggested that remodeling the barracks could reduce costs.

With the transfer of LC-130 operations from the Navy to the Air National Guard, USAP demographics in Christchurch have changed. The preventive maintenance work and inspections currently performed by the Navy's personnel in New Zealand will be performed in the U.S. by the ANG or by contract personnel in Christchurch. This reduces the need to house personnel in Christchurch to only those in transit between New Zealand and Antarctica. We expect a significant reduction in the number of people that will need to be housed at any given time.

The Office of Polar Programs and the ANG are in the process of refining the manpower requirements when the ANG assumes the LC-130 flight operations. Since the ANG is made up of full-time and part-time personnel, the numbers of people that need to be housed in Christchurch is dependent upon how many full-time and part-time personnel will be used during the operating season. The ANG is still in the process of justifying the number of full-time personnel as well as the number of transients through Christchurch. Until these manpower issues are resolved, a final cost analysis of remodeling or rebuilding the barracks versus the use of contract hotel rooms cannot be completed. OPP, in addition to developing the data to complete the cost benefit analysis, is pursuing local service contracts to reduce the number of U.S. personnel in transit that will require housing in Christchurch. Although OPP believes cost savings may be possible, the $4 million savings estimated by the OIG may be unrealistically high due to its low estimates for barracks renovation and annual operating and maintenance of barracks. It should be noted that this analysis may be impacted by the forthcoming recommendations of the U. S. Antarctic Program External Review Panel.

6. What additional costs are associated with the transition from the Navy to Air National Guard for aircraft operations, and what kinds of cost savings, and what level of cost savings, will occur for future logistics support activities as a result of the changes now underway?

Transition costs estimated at $36.5 million, consisting of one-time transition costs of $6.5 million and aircraft modifications estimated at $30 million will be incurred but will be fully recovered over an eight year period.

One-Time Transition Costs

The transition from the Navy to the ANG is a three-year plan. The ANG will ramp up support while the Navy ramps down. There is unavoidable duplication of personnel and training costs as the ANG hires additional personnel and trains them for the Antarctic mission while the Navy is still performing the function. These additional costs are estimated to be $1.5 million in FY 1996, $2.0 million in FY 1997, and $3 million in FY 1998. There will also be some contractor start-up costs associated with functions being transferred from the Navy to civilian contractors.

Aircraft Modifications

Three NSF-owned LC-130 (1970's R-model) aircraft currently operated by the Navy will be turned over to the ANG for operation and maintenance. These three aircraft require modifications for safety of operations and compatibility with Air Force systems. While NSF, Navy, and Air Force are currently reviewing and refining the requirements and estimating costs, the Air Force has stated that the total for three aircraft will not exceed $30 million.

Transition Savings

NSF estimates that annual savings of over $5 million could be realized as a result of transferring helicopter and other support operations from the Navy to civilian contractor. In fact, the contract recently awarded to a civilian contractor for helicopter support will save the USAP as much as $2.5 million per year.

In addition, NSF has estimated that as much as $9.7 million could be saved annually beginning in FY-2000 as a result of the transition from the Navy to ANG. These savings are the result of ANG and civilian operations requiring fewer personnel to perform the functions, and the fact that many of the people will be hired to perform work during the Antarctic operational season rather than year-round, as is the case currently with the Navy. NSF will reimburse the ANG only for

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the added cost to perform the Antarctic mission and not for the infrastructure already in place for the ANG wing, since that wing has an existing ANG mission. In contrast, the Navy's VXE-6 squadron has a single full-time (12-month) mission to support the USAP and is funded fully by NSF. Additionally, the smaller fleet of newer aircraft to perform both the Arctic and Antarctic missions being maintained by the ANG, rather that aircraft being maintained by both ANG and Navy, results in the need for fewer spare parts and fewer maintenance personnel.

Costs Avoided as a Result of the Transition

A major cost that will be avoided by transferring the LC-130 operations to the ANG is the need to replace six of seven NSF-owned aircraft. Three of these aircraft (two 1960's F-models and one 1970's R-model) will be permanently put out of service; three (1970's R-models) will be modified to meet Air Force safety and operations standards and will be continually maintained by the ANG. The fourth NSF aircraft (1996 H-model) is new and will not require modification.

It is possible to put NSF's older model aircraft out of service because of ANG's ability to support both polar regions with 10 aircraft (6 ANG, 4 NSF). ANG can manage the scheduling (fewer annual flight hours) and maintenance of the three 1970's R-model LC-130's to avoid their replacement before 2020. Like DC-3's and C-130A's currently in use, aircraft can be operated for as much as 50 years if properly maintained. If NSF continued to receive air support from the Navy or if air support were transferred to a commercial contractor, the NSF aircraft would have to be replaced due to the combined factors of their age and annual use. Although the aircraft could conceivably continue to be used by the USAP regardless of number of flight hours, the amount of maintenance would become impracticable. The ANG's ability to reduce the number of flight hours for the NSF aircraft by using ANG aircraft to support the mission is the most important factor in lengthening the service life of the NSF aircraft. Following established replacement schedules, new aircraft would have needed to be replaced starting in 2002. The estimate for a single aircraft (based on a similar J-model recently purchased by the British) is approximately $61 million in FY97 dollars. The estimated cost (with inflation) to replace all six aircraft with the current LC-130J model is $387 million. The $387 million minus the $30 million to modify aircraft results in a net cost avoidance of $357 million.

7. We understand that upgrades will be necessary for some of the C-130 aircraft in the Antarctic support fleet. How will the cost of these upgrades be accommodated within the budget for logistics support; how does the cost for these upgrades compare with projected cost savings for aircraft operations?

Three NSF-owned LC-130 (1970's R-model) aircraft currently operated by the Navy will be turned over to the ANG for operation and maintenance. These three aircraft require modifications for safety of operations and compatibility with Air Force systems.

Estimates for these costs have increased from early projections made in 1993 during preliminary discussions of the transfer of LC-130 operations from the Navy to the ANG. At that time estimates ranged from $3 to $9 million, spread over three years, for reconfiguring all three aircraft. It was anticipated that the $1 million to $3 million per year would be offset by expected cost-savings related to the transition of air support from Navy to ANG. While NSF, Navy, and Air Force are currently refining the requirements and estimating costs, NSF has been informed that the total for three aircraft will not exceed $30 million.

Taking into account all transition costs and all anticipated long-term savings as a result of the transition from Navy to ANG and to civilian contractor, the USAP would expect to begin seeing the monetary benefits of the transition in 2000..

Safety is a major concern for air operations in the unforgiving environment of Antarctica. What will be the safety implications of the commercialization of base support functions?

The two major areas associated with air operations that will be commercialized are the helicopter operations and air traffic control. The helicopter contract has been awarded to Petroleum Helicopters, Incorporated (PHI). PHI is a well-established helicopter contractor worldwide, serving primarily the oil industry. They currently have more than 300 contracts and fly over 200,000 hours annually. For comparison, USAP's requirements are about 2,000 hours annually. In the procurement PHI scored high in terms of safety, the highest weighted evaluation criteria. They are just completing their third year without serious accident, a very impressive statistic given an industry standard of about 9 accidents per 100,000 hours. In their proposal PHI recognized that they lack extensive experience operating in cold environments. To mitigate this, they plan to employ several recently retired VXE-6 pilots to strengthen their experience in our operating environment. OPP will use a Federal agency, the Department of Interior's Office of Aircraft Services to assist in the oversight of the contract. OAS has significant oversight expertise and experience in supporting air support contracts to the government.

The air traffic control (ATC) function will be handled by the Naval Command and Control and Ocean Surveillance Center, In-service Engineering East Coast Division (NISE-East). NISE-East is a Navy command that provides engineering support and develops operational policy for Navy ATC. They have the authority to regulate air traffic and communications. NISE-East has been serving as the USAP's engineering executive agent for ATC systems since 1987. They will now take on the added responsibility of contracting for the maintenance of ATC equipment and the controlling of airborne USAP aircraft below 60 degrees South latitude. The Navy will, therefore, still be overseeing the ATC responsibilities. However, they will be using Navy contractor personnel instead of uniform personnel. NISE-East has proven to NSF that they have the capability to set safety standards and to provide on-site monitoring of their contractor personnel to ensure safe air operations.

8. What is the formal transition plan that delineates time schedules, cost, and responsibilities during the LC-130 transition phase?

The LC-130 transition plan for logistical support of the USAP is a three-year plan that allows a gradual increase in ANG logistical support (flight hours and related support activity) while the Navy gradually withdraws support. The NSF and the Air Force continue to define the scope and level of effort (predominantly manpower and costs) of those functions to be assumed by the

ANG. Where practicable, certain support functions are being transferred to civilian agencies/contractors.

The three-year plan calls for the ANG's flight hour support to gradually increase as follows:

	1996/97 season	**1997/98 season**	**1998/99 season**
Total Flight Hours	**3600**	**3600**	**3600**
ANG-supported flight hours	800	1700	2400
% of total flight hours	*23%*	*46%*	*64%*
Navy-supported flight hours	2800	1900	1200
% of total flight hours	*77%*	*54%*	*36%*

Responsibility for the logistical support of the USAP and command of all U.S. DoD forces in Antarctica will be under Navy operational control through February 1998 (the end of the calendar 97/98 season) at which time the ANG will assume operational control and the Navy will be an augmenting force through the final year of transition, calendar year 98/99. In March 1999, the Navy will completely withdraw from logistical support of the USAP.

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